Journal of Banking and Finance 146 (2023) 106705

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Does asset encumbrance affect bank risk? Evidence from covered bonds

Emilia Garcia-Appendini[a,*], Stefano Gatti[b], Giacomo Nocera[c,*]

[a] University of Zurich, Department of Banking and Finance, Zurich, Switzerland
[b] Bocconi University, Department of Finance, Milan, Italy
[c] Audencia Business School, Department of Finance, Nantes, France

ARTICLE INFO

Article history:
Received 6 December 2021
Accepted 15 October 2022
Available online 20 October 2022

JEL Classification:
G01
G21
G28

Keywords:
Asset encumbrance
Covered bond
Market discipline
Debt priority
Bank risk

ABSTRACT

Theories suggest that asset encumbrance, the ring-fencing of certain assets for protected debtholders, can affect banks' risk-taking and lead to funding instability. We test these hypotheses using a unique, hand-collected dataset on outstanding covered bonds issued by a sample of listed European banks. Our results suggest that the effect of asset encumbrance on risk depends on the proportion of debtholders exerting market discipline and on the bank's liquidity buffers. We deal with concerns regarding omitted variables and reverse causality using several fixed effects estimations and an instrumental variables approach. Our findings can alert policymakers about potential side effects of policy interventions that can induce an increase of asset encumbrance in banks.

1. Introduction

The 2007–2009 global financial crisis and the European sovereign debt crisis that followed have increased demand for safe assets, which has acted as a catalyst for major adjustments in banks' funding models. Banks are increasingly relying on secured sources of financing, such as debt instruments that are secured by ring-fenced (or "encumbered") high-quality assets that can be claimed by the holders if the bank defaults. Covered bonds constitute one notable example of such securities. As a result of the increased demand for these instruments, the share of covered bonds as a proportion of banks' total gross bond issuance rose from 20% to 38% in the euro area from 2005 to 2018 (source: Bloomberg).

In general, market participants and policymakers have welcomed these instruments owing to their ability to serve as an additional source of funding at times when wholesale funding markets are stressed.[1] However, several voices have recently raised concerns that the asset encumbrance associated with these instruments can lead to increased risk due to the interaction with other bank stakeholders (e.g., Bank for International Settlements, 2013; International Monetary Fund, 2013). In fact, by reducing their residual claims and lowering their payment priority in case of default, asset encumbrance adversely affects the risks of unsecured debtholders and deposit holders through an increase in their losses given a default. In addition, an increased level of asset encumbrance could weaken market discipline by tilting the risk away from monitoring agents and toward depositors or other debtholders with fewer incentives to engage in monitoring, thus resulting in greater bank risk-taking.[2] Finally, for banks with reduced liquidity buffers, encumbrance can influence the likelihood of runs by unsecured creditors (Ahnert et al., 2019).

We use a unique, hand-collected dataset on outstanding covered bonds issued by listed European banks over the 2005–2016 period to empirically test whether asset encumbrance affects bank risk. Therefore, our main analysis concentrates on asset encum-

* Corresponding authors at: Giacomo Nocera, Audencia Business School, 8 route de la Jonelière, 44312 Nantes Cedex 3, France and Emilia Garcia-Appendini, University of Zurich, Department of Banking and Finance, Zurich, Switzerland.

E-mail addresses: emilia.garcia@bf.uzh.ch (E. Garcia-Appendini), stefano.gatti@unibocconi.it (S. Gatti), gnocera@audencia.com (G. Nocera).

[1] As an illustration, consider the following remark made by Jean-Claude Trichet in a keynote address at the University of Munich on July 13, 2009: "Given that the financial crisis clearly exposed the dire consequences of the imprudent evaluation of credit risk, the usefulness of more conservative asset classes such as covered bonds, which have proved to be safe assets over a long time, is obvious".

[2] Stultz and Johnson (1985) and Birchler (2000) provide theoretical support for this argument, while empirical evidence can be found in Danisewicz et al. (2018).

https://doi.org/10.1016/j.jbankfin.2022.106705
0378-4266/

brance stemming from covered bonds, which represent one of the most significant sources of European banks' asset encumbrance (EBA, 2019).[3] In an extension to our analysis, we find that our results are robust to using a more comprehensive measure of asset encumbrance.

We start our analysis by showing that an increase in asset encumbrance does not have a significant impact on overall risk for the average bank in our sample. However, we also find that unsecured debtholders are negatively affected by encumbrance, as the price of insurance against their default risk rises with asset encumbrance. This result is in line with a reduction in the seniority of these claims – i.e., "structural subordination" (EBA, 2013) – and suggests that, to reduce their expected losses, holders of unsecured debt should have higher incentives to monitor the bank following a rise in asset encumbrance. In fact, we find that the effect of asset encumbrance on bank risk exposure depends on the proportion of unsecured creditors: for banks with a smaller proportion of unsecured debtholders, an increase in asset encumbrance can lead to an overall rise in bank risk, while this relation does not hold as the share of monitoring debtholders grows.

We also provide empirical support for the theoretical prediction of Ahnert et al. (2019) that the relation between asset encumbrance and bank risk depends on the liquidity of the bank's assets. Indeed, by reducing the amount of unencumbered collateral that can be promptly liquidated quickly, asset encumbrance can lead to increased funding fragility if banks do not have enough liquidity buffers to service early withdrawals.

Identifying the effect of asset encumbrance on bank risk is particularly challenging because the use of encumbered securities may be most valuable for riskier banks. Consequently, there is plenty of scope for omitted variable or reverse causality bias. We deal with these endogeneity concerns by: (*i*) exploiting the panel dimension of our dataset, which allows us to control for time-invariant differences in the riskiness of encumbered versus unencumbered banks; (*ii*) adding year fixed effects and country group by year fixed effects to our estimations to control for time-varying differences in risk and encumbrance for all banks in our sample and in three groups of countries that could be differentially affected by endogeneity concerns (euro-core countries, euro-periphery countries, and non-euro countries); and (*iii*) comparing the within-bank changes in risk associated with changes in asset encumbrance separately for sets of observations in which endogeneity concerns are more and less likely to present themselves. Most importantly, (*iv*) we support our ordinary least squares estimations using an instrumental variables approach that exploits the exogenous variation in asset encumbrance arising from common practices in the country where the banks are located.

Our paper sheds light on the policy debate and contributes to the literature on the effects of asset encumbrance on risk and financial stability. Despite the systemic importance of this phenomenon, most extant research on the topic is policy-oriented and has been conducted by international industry associations (e.g., the European Covered Bond Council), international policy institutions (e.g., Bank for International Settlements, 2013; Beirne et al., 2011; European Banking Authority, 2012), or industry participants, such as the fixed-income departments of major European banks.

Due to limitations on data availability, academic contributions to this topic have been mainly theoretical. Gai et al. (2013) posit that encumbrance can interact with a reduced liquidity position, leading short-term secured creditors to demand more collateral, and in turn, to a further worsening of the liquidity conditions. Helberg and Lindset (2014) argue that asset encumbrance has significant effects on shareholder value but a minor impact on debtholder risk and value. Banal-Estañol et al. (2021) claim that the effect of encumbrance depends on the costs of transferring encumbered assets to the secured creditors upon default. Finally, Ahnert et al. (2019) show that the optimal level of encumbrance must reflect the tradeoff between the benefit of expanding profitable investments funded by cheaper senior secured debt, and the cost of greater fragility from runs on unsecured debt. We derive some of the testable implications in our empirical analysis from the insights developed in these theories.

Our contribution to the literature is twofold. First, we present novel evidence showing that the relation between encumbrance and risk depends on the structure of the banks' existing liabilities, especially the proportion of debtholders who move down on the priority ladder with encumbrance. Our results show that encumbrance can be mostly beneficial for banks with a large proportion of such debtholders, but it can negatively affect risk if existing debtholders do not exert market discipline. Second, we present evidence consistent with a negative relation between encumbrance and risk that is moderated by higher levels of liquid assets. Our findings can alert policymakers about potential side effects of policy interventions that can induce an increase of asset encumbrance in banks, such as the ECB's covered bond purchase programs (CBPPs).

2. Theoretical framework and development of hypotheses

By reducing funding costs and promoting investments in safe assets, asset encumbrance should, in principle, have a mitigating effect on bank risk. However, asset encumbrance changes the *de facto* debt priority structure of the bank in at least two key ways. On the one hand, asset encumbrance introduces a new class of claimants who enjoy top priority in case of default and are secured by safe collateral. These new debtholders have few incentives to prevent an increase in the risk associated with the assets outside the cover pool. As shareholders have an option-like claim on the firm's residual cash flows, which increases with risk (Galai and Masulis, 1976; Jensen and Meckling, 1976; Fama, 1978), they might encourage policies that raise the risk levels of the assets outside the cover pool (see also Helberg and Lindset, 2014). On the other hand, asset encumbrance changes the debt priority structure of existing unsecured debtholders. By ring-fencing high-quality assets to the benefit of the covered bondholders, the introduction of asset encumbrance lowers the priority ranking of unsecured debtholders and increases the risk associated with their claims. Following the arguments in Birchler (2000) and empirical evidence in Danisewicz et al. (2018), this should increase the monitoring intensity of unsecured debtholders due to their greater losses in the event of bankruptcy. In other words, the lower prioritization of the unsecured debtholders might lead them to exert greater market discipline (Calomiris and Kahn, 1991; Calomiris, 1999; Martinez-Peria and Schmuckler, 2001; Bliss and Flannery, 2002).

The above arguments indicate that the net effect of asset encumbrance on bank risk is ambiguous, which we summarize in the following two opposing hypotheses:

H1a*: The net effect of asset encumbrance on bank risk is positive.*

H1b*: The net effect of asset encumbrance on bank risk is negative.*

The above arguments also suggest that an important determinant of whether bank risk would increase or decrease due to asset encumbrance is the propensity of creditors to exert market discipline. In particular, we expect the asset-substitution problem associated with an increase in asset encumbrance to be less severe in banks with a high proportion of senior unsecured debtholders than in banks with a low proportion of senior unsecured creditors. As explained above, this is because asset encumbrance decreases the seniority of these creditors and converts them into *de facto*

[3] Section IA.1 in the Appendix describes the institutional background of covered bonds, and how these give rise to asset encumbrance.

subordinated creditors, increasing both their loss given default and their incentives to monitor and limit the bank's risk-taking. A necessary condition for greater monitoring intensity of the unsecured debtholders is that asset encumbrance increases the risk of unsecured debtholders. This constitutes our second testable hypothesis:

***H2**: Asset encumbrance increases the risk of unsecured debtholders.*

If *H2* is true, then we expect a milder increase in risk-taking incentives following an increase in asset encumbrance if the proportion of unsecured debtholders in the bank is high, as these stakeholders will exert market discipline. In contrast, if the share of monitoring debtholders is low, there might be fewer countervailing forces to shareholders' incentives to increase risk, leading to an overall increase in the levels of bank risk following asset encumbrance. This constitutes our third testable hypothesis:

***H3**: The effect of asset encumbrance on bank risk depends on the proportion of unsecured debtholders.*

Asset encumbrance can also increase bank risk by making banks more fragile and prone to runs by unsecured debtholders. According to Gai et al. (2013) and Ahnert et al. (2019), a high asset encumbrance level has two opposing effects. On the one hand, asset encumbrance supports funding diversity, which helps alleviate funding constraints and allows for the financing of profitable investments. On the other hand, in the presence of asymmetric information, it can lead to fragility by reducing the amount of unencumbered collateral that can be liquidated to service early withdrawals, which in turn may entail fire sales, a decrease in new banking activities, and greater investor concern about bank soundness. These effects can be amplified during economic downturns, as falling collateral asset values require replenishing the cover pool to maintain the credit rating of the outstanding secured debt (Bank for International Settlements, 2013).

We hypothesize that the negative effects of asset encumbrance in terms of fragility should dominate in banks that do not have sufficient liquidity buffers to deal with early withdrawals or during periods of liquidity shortage, such as the 2007-2009 financial crisis.[4] This constitutes our fourth testable prediction:

***H4**: The effect of asset encumbrance on risk depends on the bank's liquidity buffers.*

3. Data and methodology

3.1. Sample and data sources

We conduct our main tests on a sample consisting of all listed commercial banks headquartered in any European country experiencing at least one covered bond issuance during the 2005–2016 period.[5] Our bank-specific asset encumbrance measure is based on the amount of outstanding covered bonds each year. This hand-collected measure is derived from Dealogic's DCM information regarding the amount, issue date, maturity, and other characteristics of each bank's covered bond issuances from 1995, ten years before the start of our sample period.[6] One key difficulty in computing this measure is that the data provider assigns the name of the parent company to each deal issuance *at the time of the downloading* of the data. For this reason, we manually track the complete ownership history of every bank over the sample period in order to assign all outstanding covered bond amounts to the parent company which ultimately holds the outstanding debt at each time t.[7] To do so, we use information from Dealogic M&A, Zephyr, and as well, we manually collect information about the parent company holding the outstanding covered bonds over time from Moody's Analytics BankFocus ownership database, banks and central bank's websites and newspaper articles obtained from Factiva. After all bond issuances are assigned to the correct parent company, we define the amount of covered bonds outstanding in bank i at time t as the sum of all covered bonds issued by bank i (or any of its subsidiaries) when t is between the deal-pricing date and the maturity date. To the best of our knowledge, the resulting sample is the only database to contain a proxy for asset encumbrance at the bank level over an extended period of time.

Evaluating the effects of asset encumbrance by looking only at covered bonds may raise concerns that this variable does not account for other instruments that also contribute to encumbrance, such as repos, security borrowing, and derivative claims. To deal with this concern, we hand-collect a more comprehensive measure of asset encumbrance using voluntary disclosures to the European Banking Authority (EBA). This data is available for 58 banks in our sample, for a total of 105 bank-year observations from years 2014 and 2015.[8] While the overall encumbered asset ratio is 18% higher than our measure, we find that both measures correlate positively, with a pairwise correlation of 0.546. This result suggests that our measure of asset encumbrance is a good proxy for the bank's overall asset encumbrance level. In an extension to our analysis, we find that our main results are robust to using this alternative measure of asset encumbrance.

Our main bank risk measures are the distance to default (*DTD*), which we obtain from the Credit Research Initiative of the National University of Singapore (CRI dataset), and CDS spreads which we obtain from Markit. We control for several bank balance-sheet characteristics which we source from Moody's Analytics BankFocus database. Details on the computation of all variables used in our regressions are available in the Appendix. Throughout our analysis, banks are observed at the parent-company or bank-holding level in order to avoid potential bias in the risk measures arising from the fact that a parent entity can act as guarantor on its subsidiaries' liabilities.[9]

3.2. Methodology

To evaluate the effect of asset encumbrance on bank risk and test *H1* and *H2*, we estimate the coefficients of the following basic

[4] Papers that document the bank runs during the crisis include Ippolito et al. (2016) for runs on both bank assets (credit lines) and liabilities (wholesale uninsured deposits), Gorton and Metrick (2011) for runs on repo funding, and Covitz et al. (2013) for runs on asset-backed commercial paper programs.

[5] We focus on Europe due to its dominance in the covered bonds market. In fact, across our sample period, the share of European covered bonds ranged between 92% and 99% of the worldwide market (ECBC, 2019). We exclude countries without covered bond issuances due to the inexistence of a regulatory framework or legal basis for these instruments. Note that these sample restrictions do not affect the estimations in the intensive margin.

[6] The average maturity of covered bonds is six years, the median is five years, and 90% of the covered bonds have a maturity of 10 years or less. Aggregation at the yearly level is necessary because the balance-sheet information is at this level.

[7] Consider, for example, the case of HypoVereinsbank (HVB) and UniCredit. HVB was bought by UniCredit in 2005. At the time of data downloading, the data provider assigned all of HVB's covered bond issuances before 2005 to UniCredit. Our procedure allows us to assign these issuances to HVB. Similarly, on December 2006, two listed Italian banks, Sanpaolo IMI and Banca Intesa, merged to form Intesa Sanpaolo. Consequently, the data provider attributed all of Sanpaolo IMI's issuances before 2006 to Intesa Sanpaolo, while our procedure allows us to assign them to Sanpaolo IMI.

[8] Asset encumbrance measures are available from the EBA only since year 2014, are based on voluntary disclosures of total asset encumbrance, and have different degrees of reporting detail across banks. The data therefore are not available for all banks, and the level of disclosure is heterogeneous across reporting banks.

[9] Focusing on the parent holdings rather than individual subsidiaries also facilitates the attribution of debt issuances to the bank, as it is common for European banks to use special-purpose entities to issue debt (Camba Mendez et al., 2014). In addition, as banks are usually listed at the holding level, focusing on the parent level allows us to evaluate banks' risk exposure using market-based indicators that are unavailable at the subsidiary level.

regression equation:

$$RISK_{i,t} = \beta_0 + \beta_1 CB_{i,t-1} + \gamma X_{i,t-1} + \delta_t + \eta_i + \varepsilon_{i,t} \quad (1)$$

The dependent variable for *H1* is the distance to default, *DTD* (an inverse measure of bank risk), because it is a complete and unbiased indicator of bank risk (Gropp et al., 2006) which does not refer to a particular category of creditor nor to a particular source of bank asset risk. For tests of *H2*, we are instead interested in the risk exposure of unsecured creditors; therefore, we adopt the senior debt CDS spread (*SPREAD*) as the relevant risk variable.

Variable *CB* measures the degree of asset encumbrance in the bank. Our extensive margin measure of asset encumbrance is *CB USER*, a dummy variable which equals 1 if the bank has any amount of covered bonds outstanding, and zero otherwise. For the intensive margin, we use the ratio of the total amount of covered bonds outstanding to total assets (variable *CB RATIO*), which is only defined in the subsample of banks where *CB USER* = 1. To limit reverse causality concerns, we lag our asset encumbrance measures and all controls by one year.

The main coefficient of interest in tests of *H1* and *H2* is β_1, which measures the direct effect of asset encumbrance on bank risk. *H1a* and *H1b* propose that the sign of this coefficient could be positive or negative. In contrast, *H2* suggests a positive relation between the risk of unsecured debtholders and the bank's asset encumbrance.

Our main set of testable hypotheses, *H3* and *H4*, suggest heterogeneous effects of asset encumbrance on bank risk that depend on the bank's market discipline and on the liquidity buffers, respectively. To test these hypotheses, we employ the following interacted regression equation:

$$\begin{aligned} RISK_{i,t} = {} & \beta_0 + \beta_1 CB_{i,t-1} + \beta_2 BKCHAR_{i,t-1} + \beta_3 CB_{i,t-1} \times BKCHAR_{i,t-1} \\ & + \gamma X_{i,t-1} + \delta_t + \eta_i + \varepsilon_{i,t} \end{aligned} \quad (2)$$

In this case the main coefficient of interest is the interaction coefficient between asset encumbrance and a given bank characteristic (*BK CHAR*). For tests of *H3*, this refers to the degree of market discipline in the bank, whereas for *H4* it refers to bank liquidity.

To measure market discipline, we recall that asset encumbrance affects the monitoring incentives of those debtholders who become structurally subordinated. Consequently, in our framework, the most relevant monitoring debtholders are the senior unsecured debtholders, as the structural subordination induced by asset encumbrance lowers their priority ranking. Thus, our main measure for market discipline is the ratio of the bank's senior liabilities (i.e., assets net of equity, deposits, subordinated borrowings, and outstanding covered bonds) to its non-equity liabilities.[10] *H3* postulates that risk should increase with asset encumbrance when market discipline is low. Given that we use an inverse measure of risk as the dependent variable, we expect a positive coefficient for the interaction term.

We measure bank liquidity with the ratio of liquid assets to total assets in the bank's portfolio. *H4* posits that the effect of asset encumbrance on bank fragility is stronger for banks with low liquidity buffers. Therefore, we also expect a positive coefficient for the interaction term in this case.

We control for several bank-specific variables that could be related to the use of covered bonds and affect banks' risk-taking: bank size; the ratio of bank total loans to total assets; and the bank's ratio of equity to total assets. By keeping the capital ratio fixed, our specifications allow for changes in the risk of banks given the same level of bank leverage. Thus, any rise in the level of risk should not be due to increases in leverage associated with changes in the asset encumbrance. Finally, we control for macroeconomic conditions by adding the annual growth rate for gross domestic product; the country CDS spread; and, to capture the value of one of the main collateral assets for covered bonds, the growth in real house prices in the country where the bank is located.

As mentioned before, all independent variables are lagged one year to mitigate reverse causality concerns. In addition, all specifications include bank fixed effects to control for time-invariant, unobserved bank and country characteristics that may simultaneously affect the risk and use of covered bonds.[11] This limits the concern that our estimates capture unobserved bank characteristics that lead to higher risk and higher asset encumbrance in the cross section. We also include year fixed effects, δ_t, to control for events that were common to all banks in our sample in a particular year. Finally, in some of our specifications we include country group by year fixed effects for three groups of countries: euro "core" countries (Austria, Belgium, Finland, France, Germany, and the Netherlands), euro "periphery" countries (Cyprus, Greece, Ireland, Italy, Portugal, and Spain), and non-euro countries (the remainder).[12] These fixed effects control for the concern that the financial and sovereign debt crises had larger effects on the peripheral countries of the Eurozone, leading to substantial increases in bank risk in these countries. In section 5 we discuss and address other endogeneity issues.

3.3. Descriptive statistics

Our final sample consists of 909 bank-year observations for 100 unique banks across 21 countries.[13] Table 1 reports sample descriptive statistics for the main variables used in our analysis. To ensure consistency with the regression analysis, all dependent variables in this table are measured at time *t* and independent variables are measured at *t*-1. Panel *A* contains statistics for the entire sample of banks. Panel *B* contains means and standard deviations for banks that do not rely on covered bonds as a source of funding (*CB USER* = 0) and those that do (*CB USER* = 1). The last columns in Panel *B* contain the significance of the difference in means of each variable across the subsamples.

Panel *A* of Table 1 shows that the banks in our sample have an average asset value of roughly EUR 330 billion, but there is significant variation in the cross section. On average, 58% of the banks' assets consist of loans and 18% of all assets are liquid. In terms of the liability structure, banks have an average capital ratio of 6%, and almost half (47%) of banks' liabilities consist of senior liabilities. However, there is significant variation across the banks in our sample.

In Panel *B* of Table 1, we find that banks with outstanding covered bonds are, on average, riskier than non-covered bond users. This highlights the importance of obtaining a panel dataset with values for banks' risk and use of covered bonds, and of employing a fixed effects approach to control for endogeneity in the cross section. Other significant differences between users and non-users

[10] Our measure denotes the weight of debtholders who are more likely to be affected by the structural subordination triggered by covered bond issuance over all debtholders. We therefore exclude depositors, covered bondholders, and subordinated bondholders (who have junior priority even in the absence of covered bond issues and should therefore not experience significant changes in their monitoring incentives). Thus, our measure mainly refers to bondholders. According to the European System of Central Banks (ESCB), 85% of all bondholders correspond to banks and other institutional investors such as mutual funds, which are likely to exert market discipline.

[11] Bank fixed effects also address any concerns of reverse causality between persistent variables.

[12] Finer estimations with country × year fixed effects are implausible in our setup because there is a limited number of banks in each country-year cell, which severely limits the within-country-and-year variation (see Table IA.1 in the Internet Appendix).

[13] Tables IA.1 and IA.2 in the Internet Appendix contain tabulations of the number of observations in our sample and descriptive statistics of our main dependent variables by country and year.

Table 1
Sample descriptive statistics.

Panel *A*. Summary statistics

Variable	N	Mean	S. Dev.	Min	25th %tile	Median	75th %tile	Max
DTD	909	1.216	1.699	-1.869	-0.032	0.996	2.282	5.913
SPREAD	946	174.970	241.924	7.390	32.820	109.505	195.010	1541.220
CB USER	909	0.576	0.494	0.000	0.000	1.000	1.000	1.000
CB RATIO	524	0.062	0.068	0.000	0.014	0.044	0.081	0.488
SENIOR	860	0.474	0.183	0.017	0.362	0.476	0.593	0.934
LIQUIDITY	909	0.181	0.117	0.014	0.096	0.158	0.235	0.599
CAPITAL	909	0.062	0.025	0.010	0.044	0.060	0.075	0.185
TOTAL ASSETS	909	330.842	484.626	1.220	26.923	89.744	428.495	1907.160
SIZE	909	18.405	1.730	14.014	17.108	18.312	19.876	21.369
LOANS	909	0.578	0.163	0.134	0.495	0.609	0.690	0.921
GDP GROWTH	909	0.874	3.045	-9.132	-0.244	1.313	2.556	26.276
COUNTRY SPREAD	909	171.446	807.254	0.000	8.000	31.670	102.160	10132.510
Δ *HOUSE PRICE*	909	0.003	0.069	-0.195	-0.036	0.002	0.039	0.683
CB OTHERS	897	0.053	0.067	0.000	0.003	0.029	0.083	0.496

Panel B. *T*-tests for non-covered bond users vs covered bond users.

	CB USER = 0			*CB USER* = 1				
	Mean	S. Dev.	N	Mean	S. Dev.	N	*t*	*p*-value
DTD	1.561	1.777	385	0.963	1.594	524	5.235	0.000
SPREAD	112.226	197.997	244	196.778	251.918	702	-5.336	0.000
CB USER	0.000	0.000	385	1.000	0.000	524	-	-
CB RATIO	0.000	0.000	385	0.062	0.068	524	-20.915	0.000
SENIOR	0.440	0.207	351	0.497	0.160	509	-4.341	0.000
LIQUIDITY	0.184	0.107	385	0.179	0.124	524	0.644	0.519
CAPITAL	0.068	0.025	385	0.057	0.025	524	6.234	0.000
TOTAL ASSETS	115.677	262.160	385	488.931	546.051	524	-13.652	0.000
SIZE	17.288	1.481	385	19.225	1.412	524	-19.868	0.000
LOANS	0.610	0.145	385	0.555	0.171	524	5.299	0.000
GDP GROWTH	1.102	2.866	385	0.707	3.162	524	1.966	0.050
COUNTRY SPREAD	126.071	619.907	385	204.784	920.102	524	-1.540	0.124
Δ *HOUSE PRICE*	0.014	0.075	385	-0.005	0.064	524	3.964	0.000
CB OTHERS	0.022	0.035	379	0.075	0.075	518	-14.130	0.000

Panel *A* contains summary statistics for the main variables used in this analysis for the entire sample of banks (with the exception of *CB RATIO* measured on the subsample of banks with outstanding covered bonds only): *DTD* is the distance to default; *SPREAD* is the CDS spread; *CB USER* is a dummy that identifies banks with outstanding covered bonds; *CB RATIO* is the ratio of the amount of the bank's total outstanding covered bonds to its total assets; *SENIOR* is the ratio of senior liabilities (assets net of equity, deposits, subordinated borrowings, and outstanding covered bonds) to total liabilities net of equity; *LIQUIDITY* is the ratio of liquid assets to total assets; *CAPITAL* is the ratio of the bank's equity to its total assets; *TOTAL ASSETS* is the amount (in EUR billion) of the bank's total assets; *SIZE* is the natural logarithm of the bank's total assets; *LOANS* is the ratio of loans to total assets; *GDP GROWTH* is the GDP growth rate in the country where the bank is domiciled; *COUNTRY SPREAD* is the CDS spread in the country where the bank is domiciled; Δ *HOUSE PRICE* is the growth in house prices in the country; *CB OTHERS* is the average ratio of outstanding covered bonds to total assets of all other public and private banks in the same country and year.
Panel *B* contains the means and standard deviations of the main variables separately for the sample of banks with no outstanding covered bonds (*CB USER* = 0) and for banks with outstanding covered bonds (*CB USER* = 1). The last two columns report the results of the *t*-test for the equality of variable means and the corresponding *p*-value.
Precise variable definitions are in provided in the Appendix.

of covered bonds relate to their size, capitalization, liquidity, and the business model: covered bond users are larger, relatively less capitalized, rely less on senior liabilities for funding, provide fewer loans, and exhibit a lower ratio of liquid assets than non-users of covered bonds. These differences highlight the importance of controlling for these variables in a regression setup.

4. Results

4.1. Asset encumbrance and bank risk

Table 2 reports the results of estimating Equation (1) using ordinary least squares regressions to test *H1a* and *H1b*. In columns 1 to 5, we estimate the impact of asset encumbrance on bank risk on the extensive margin; columns 6 to 10 focus on the intensive margin. The estimated coefficients in columns 1 to 3 and 6 to 10 of Table 2 are negative, which may suggest an overall decrease in risk due to encumbrance for the average bank in our sample. However, the coefficients switch signs in columns 4 and 5, and they are not statistically significant except in columns 1 and 6. These findings suggest that the positive and negative effects of covered bonds outlined in section 2 offset each other for the average bank in our sample. The lack of significant results and of any empirical dominance of either *H1a* or *H1b* also highlights the importance of examining the risk sensitivity of asset encumbrance for banks that are more likely to be affected by it, either due to a low proportion of monitoring debtholders (*H2* and *H3*) or because liquidity buffers are low (*H4*).

4.2. Asset Encumbrance and Unsecured Debtholders' Risk

We next examine whether asset encumbrance affects the CDS spread. Results are provided in Table 3. Consistent with *H2*, we find that covered bonds have a significant negative impact on senior unsecured debtholders' risk, as shown by the significant increase in the CDS spreads of covered bond users in both the extensive margin (columns 1–5) and the intensive margin (columns 6–9). Economically, the estimated coefficients are also significant. For example, the coefficient in column 5 suggests that the issuance of covered bonds increases CDS spreads by 44 basis points, or 16%

Table 2
Asset encumbrance and bank risk.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CB USER	-0.397*	-0.155	-0.111	0.021	0.032					
	(-1.756)	(-0.750)	(-0.562)	(0.101)	(0.150)					
CB RATIO						-5.173*	-3.434	-2.885	-2.249	-2.380
						(-1.948)	(-1.454)	(-1.277)	(-1.061)	(-1.106)
CAPITAL		24.337***	20.782***	23.595***	21.860***		19.646***	17.550***	19.412***	19.570***
		(5.930)	(5.159)	(6.026)	(5.809)		(3.565)	(3.039)	(3.438)	(3.479)
SIZE		-0.518	-0.244	-0.569	-0.311		-0.405	-0.244	-0.445	-0.331
		(-1.553)	(-0.794)	(-1.604)	(-0.925)		(-0.790)	(-0.469)	(-0.936)	(-0.694)
LOANS		-0.276	0.855	-0.206	0.398		1.407	1.879	0.397	0.751
		(-0.264)	(0.818)	(-0.186)	(0.348)		(0.895)	(1.223)	(0.219)	(0.425)
GDP GROWTH			0.049**		0.052**			0.030		0.044
			(2.085)		(2.208)			(1.052)		(1.355)
COUNTRY SPREAD			-0.000		-0.000			0.000		0.000
			(-1.612)		(-0.218)			(0.293)		(1.041)
Δ *HOUSE PRICE*			3.831***		2.433***			1.353		-0.058
			(3.690)		(2.816)			(1.049)		(-0.038)
No. of obs.	909	909	909	909	909	521	521	521	521	521
R^2	0.570	0.611	0.632	0.664	0.673	0.614	0.640	0.644	0.682	0.687
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds to test *H1*. The analysis is performed on the entire sample (columns 1–5) and on the subsample of banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variable is a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10). Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. Specifications in columns 1–3 and 6–8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country-group × year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3
Asset encumbrance and unsecured debtholders' risk.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CB USER	106.709***	86.334***	55.542***	64.433***	43.611***					
	(2.622)	(3.742)	(3.082)	(3.252)	(2.619)					
CB RATIO						710.780***	560.316***	259.008*	285.923**	148.917
						(3.286)	(3.961)	(1.905)	(2.356)	(1.166)
CAPITAL		-3,411.996***	-645.490	-2,259.384***	-369.215		-2,368.541**	124.195	-1,804.110**	-154.976
		(-3.968)	(-0.874)	(-3.091)	(-0.548)		(-2.232)	(0.151)	(-2.074)	(-0.201)
SIZE		-5.941	-11.142	-15.307	-11.534		-14.949	-56.227*	-31.886	-45.767*
		(-0.201)	(-0.462)	(-0.611)	(-0.493)		(-0.480)	(-1.895)	(-1.144)	(-1.650)
LOANS		60.652	-142.734	50.047	-29.353		-55.917	-322.203**	-89.540	-164.649
		(0.546)	(-1.408)	(0.481)	(-0.294)		(-0.380)	(-2.171)	(-0.618)	(-1.098)
GDP GROWTH			-24.563***		-19.524***			-17.067***		-11.109***
			(-3.861)		(-4.452)			(-3.826)		(-3.960)
COUNTRY SPREAD			0.099***		0.085***			0.067***		0.052***
			(5.722)		(6.335)			(5.142)		(4.715)
Δ *HOUSE PRICE*			-297.538**		-176.361			-548.170***		-347.493**
			(-2.168)		(-1.326)			(-3.789)		(-2.305)
No. of obs.	946	946	946	946	946	701	701	701	701	701
R^2	0.637	0.657	0.765	0.754	0.808	0.782	0.789	0.845	0.862	0.881
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of unsecured creditor's risk on the use of covered bonds to test for *H2*. The analysis is performed on the entire sample of banks for which CDS spread information is available (columns 1–5) and on the subsample of banks with CDS spread information and outstanding covered bonds (columns 6–10). The dependent variable is the bank's CDS spread (*SPREAD*). The main explanatory variable is a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10). Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. All specifications include bank fixed effects. Specifications in columns 1–3 and 6–8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country group × year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4
Asset encumbrance, market discipline, and bank risk.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD
CB USER	-2.015***	-1.487***	-1.255**	-0.847*	-0.775					
	(-3.841)	(-2.716)	(-2.411)	(-1.791)	(-1.659)					
CB RATIO						-22.143***	-20.454***	-19.541***	-17.070***	-18.157***
						(-4.641)	(-4.546)	(-4.538)	(-3.694)	(-3.943)
SENIOR	-4.499***	-2.472*	-1.841	-2.693**	-2.373*	-5.354***	-3.940***	-3.648**	-4.782***	-5.135***
	(-3.848)	(-1.780)	(-1.405)	(-2.145)	(-1.932)	(-4.865)	(-2.793)	(-2.628)	(-3.713)	(-4.055)
CB × *SENIOR*	3.306***	2.687**	2.328**	1.705*	1.602*	38.512***	42.527***	41.441***	33.757**	34.507**
	(3.323)	(2.601)	(2.378)	(1.924)	(1.830)	(2.664)	(2.999)	(2.977)	(2.433)	(2.592)
CAPITAL		26.291***	22.652***	23.788***	21.996***		17.643***	17.142***	16.212***	17.570***
		(5.844)	(4.937)	(5.955)	(5.705)		(2.957)	(2.757)	(3.130)	(3.463)
SIZE		-0.146	0.055	-0.196	0.011		-0.738*	-0.616	-0.687*	-0.662*
		(-0.413)	(0.168)	(-0.568)	(0.034)		(-1.944)	(-1.549)	(-1.873)	(-1.833)
LOANS		0.178	1.099	-0.165	0.267		-0.172	0.179	-1.930	-1.942
		(0.163)	(1.020)	(-0.134)	(0.215)		(-0.099)	(0.100)	(-1.012)	(-1.017)
GDP GROWTH			0.036		0.040			0.026		0.045
			(1.555)		(1.645)			(0.914)		(1.374)
COUNTRY SPREAD			-0.000		0.000			0.000		0.000*
			(-1.066)		(0.183)			(0.819)		(1.971)
Δ *HOUSE PRICE*			4.154***		2.388**			0.649		-1.370
			(3.734)		(2.363)			(0.486)		(-0.867)
No. of obs.	860	860	860	860	860	506	506	506	506	506
R^2	0.585	0.619	0.637	0.669	0.676	0.644	0.663	0.665	0.705	0.712
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds under different levels of market discipline to test *H3*. The analysis is performed on the entire sample (columns 1–5) and on the subsample of banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10); the ratio of the bank's senior liabilities to its total liabilities (*SENIOR*); and the interaction between either *CB USER* or *CB RATIO* and *SENIOR*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. Specifications in columns 1–3 and 6–8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country-group by year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

of the variation in this variable in our sample. The effect in the intensive margin is somewhat smaller but still significant in columns 6 to 9, and marginally significant (T-statistic of 1.16) in column 10. For example, the coefficients in columns 9 and 10 suggest that a one standard deviation increase in the amount of outstanding covered bonds (0.068) increases the spread by an additional 10 (= 149 × 0.068) to 19 (= 286 × 0.068) basis points, which corresponds to between 4% and 7% of the standard deviation in the spread. Thus, we find that unsecured debtholders are strongly affected by asset encumbrance. It is therefore plausible that the incentives of senior unsecured debtholders to exert market discipline strengthen with the introduction of covered bonds.

4.3. Asset encumbrance, risk, and bank monitoring

Table 3 shows that the necessary condition for *H3* is satisfied. In Table 4, we formally test this hypothesis using Equation (2). As before, columns 1 to 5 (6 to 10) focus on the extensive (intensive) margin. Results show that the non-interacted coefficient for the covered bond variables is always negative, and it is statistically significant in all columns of Table 4 except column 5. Consistent with *H3*, this suggests that asset encumbrance increases risk for those banks with the lowest level of market discipline (*SENIOR* = 0). Further confirming *H3*, the coefficient of the interaction term is positive and significant in all specifications, which shows that the increase in risk due to asset encumbrance is significantly lower for banks with a large proportion of monitoring debtholders.

As discussed by Brambor et al. (2006), a complete analysis of interaction models, such as the one in Equation (2), should include an assessment of the marginal effects over different ranges of the interacted variable. Even interaction terms that have statistically insignificant coefficients could lead to statistically significant marginal effects for some range of the interacted variables. In line with these authors' recommendations, we plot the estimated marginal effects of covered bonds on risk (solid lines) and their 90% confidence intervals (dashed lines) over all possible ranges of the proportion of senior monitoring debtholders, *SENIOR*, in Fig. 1. Panel *A* of Fig. 1 contains estimates of the marginal effect of asset encumbrance on risk for the extensive margin, while Panel *B* corresponds to the intensive margin.[14] The figure shows that the marginal effect of covered bonds on risk increases with the share of senior liabilities (as demonstrated by the positive slope of the marginal effects in both panels). Panel *A* shows that for banks with proportions of senior liabilities below roughly 40%, the usage of covered bonds significantly increases risk. As predicted, this effect declines as the ratio of senior unsecured debtholders and, therefore, incentives to exert market discipline increase. When the proportion of senior liabilities is higher than 80%, the market discipline effect prevails and the net effect of covered bond usage on risk becomes statistically positive, implying that asset encumbrance reduces risk in such banks. The results in the intensive margin (Panel *B*) are qualitatively similar, showing that asset encumbrance significantly increases risk if the proportion of senior unsecured debtholders is below roughly 40%, and decreases risk if the proportion is above approximately 75%. Notice that the marginal effect is imprecisely estimated for the range of values of *SENIOR* that includes the average value of this variable for the banks in our sample (0.48). This explains why we did not find any significant ef-

[14] The values in Panel *A* (*B*) of Figure 1 are computed on the estimates in column 3 (8) of Table 4.

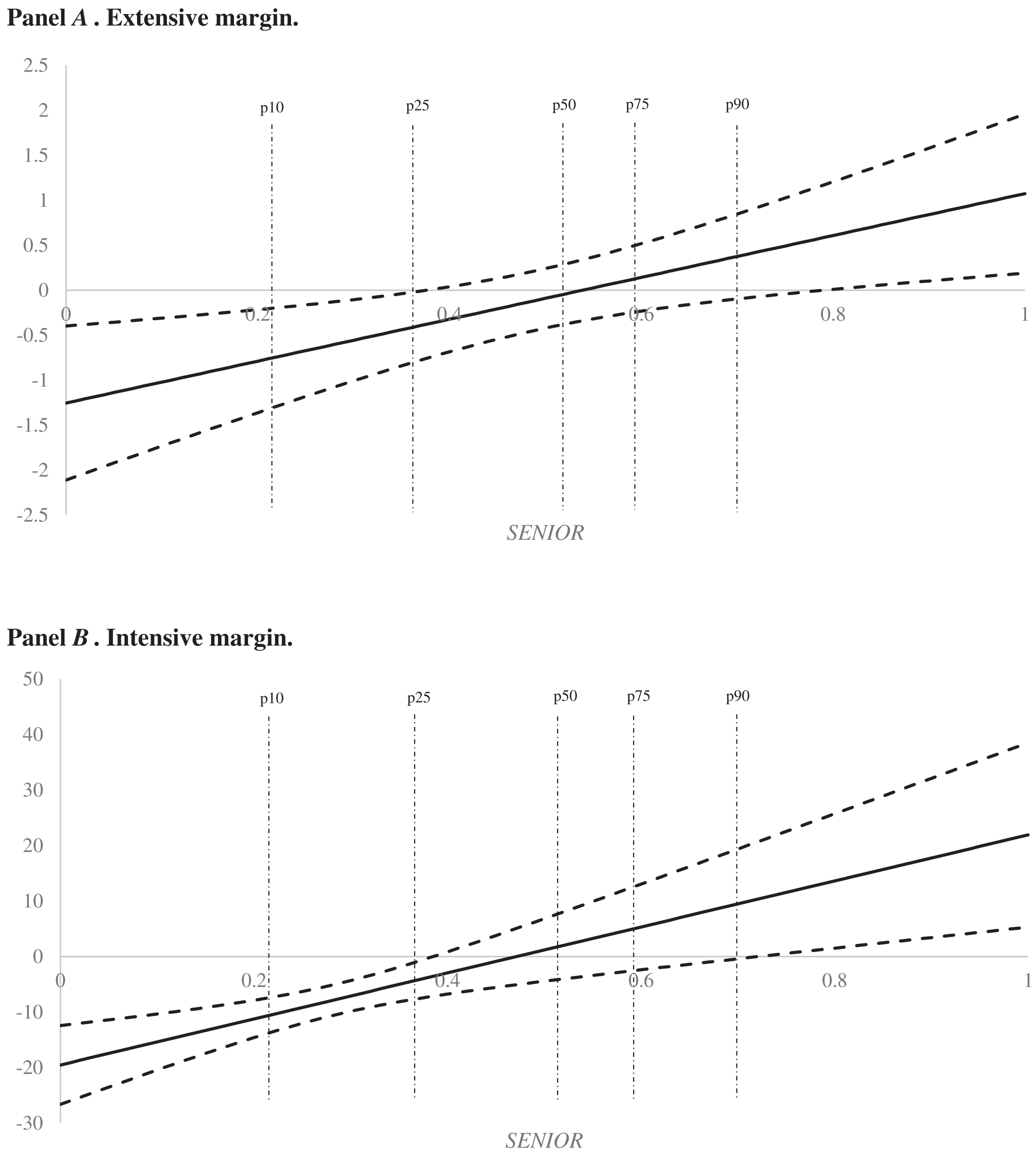


Fig. 1. Marginal effect of covered bond usage on distance to default for different levels of market discipline.
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's market discipline (as measured by *SENIOR*, the ratio of senior non-deposit liabilities to total liabilities). Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's market discipline. The estimates correspond to those in column 3 of Table 4. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's market discipline. The estimates correspond to those in column 8 of Table 4. Vertical lines correspond to percentiles in the distribution of *SENIOR*.

fect in the estimations in Table 2, and highlights the importance of accounting for the heterogeneity in market discipline across banks when we account for the effect of asset encumbrance on risk.

The effects are also economically sizeable. For example, for a bank with a proportion of senior unsecured debtholders in the twenty-fifth percentile (0.36), the marginal effect is –0.42 in the extensive margin. This suggests that an issuance of covered bonds leads to an increase in risk that accounts for 24.5% (= 0.42/1.699) of the total variation in risk. In the intensive margin, the marginal effect when the same bank increasing the use of covered bonds by one standard deviation (0.068) equals –0.315, which accounts for 18.5% of the variation in risk.

4.4. Asset encumbrance, risk, and bank liquidity

We now move to a test of *H4*, which posits that there should be a positive coefficient for the interaction of liquidity with our measures of asset encumbrance. Results are presented in Table 5. As usual, columns 1 to 5 (6 to 10) focus on the extensive (intensive) margin. The negative coefficients for the non-interacted covered bond variables suggest that augmenting asset encumbrance increases bank fragility for banks with zero liquidity. This result is statistically significant in all specifications for the intensive margin, but only in column 1 for the extensive margin. We also find that the coefficient of the interaction term is positive throughout the columns, as expected, suggesting that the rise in risk is lower for banks with increasing levels of liquidity. However, the coefficients are only statistically significant in the intensive margin, suggesting that what matters for fragility in banks with low liquidity is the intensity of asset encumbrance.

To ease the interpretation of these results, in Panels *A* and *B* of Fig. 2 we illustrate the marginal effects (solid line) and 90% confidence intervals (dashed lines) for the estimates contained in columns 3 and 8 of Table 5, respectively. The results show that the

Table 5
Asset encumbrance, liquidity, and bank risk.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD	DTD
CB USER	-0.768**	-0.427	-0.338	-0.099	-0.082					
	(-2.621)	(-1.393)	(-1.148)	(-0.358)	(-0.310)					
CB RATIO						-13.495***	-10.370***	-9.556***	-8.233**	-8.116**
						(-3.313)	(-2.998)	(-2.868)	(-2.486)	(-2.418)
LIQUIDITY	0.160	1.068	0.940	-0.092	-0.019	-1.789	-0.542	-0.494	-1.042	-1.394
	(0.120)	(0.715)	(0.664)	(-0.071)	(-0.014)	(-1.303)	(-0.417)	(-0.376)	(-0.797)	(-1.076)
CB × LIQUIDITY	2.579	2.068	1.737	0.764	0.745	54.975**	45.877**	43.750**	37.555**	35.444*
	(1.516)	(1.164)	(0.994)	(0.497)	(0.473)	(2.621)	(2.388)	(2.315)	(2.014)	(1.954)
CAPITAL		24.346***	20.921***	23.535***	21.825***		18.525***	16.709***	18.837***	19.179***
		(6.009)	(5.241)	(6.047)	(5.823)		(3.401)	(2.926)	(3.363)	(3.450)
SIZE		-0.490	-0.224	-0.577	-0.316		-0.295	-0.163	-0.351	-0.277
		(-1.446)	(-0.723)	(-1.659)	(-0.957)		(-0.563)	(-0.300)	(-0.754)	(-0.584)
LOANS		0.498	1.501	-0.143	0.486		1.585	1.982	0.566	0.709
		(0.418)	(1.250)	(-0.119)	(0.393)		(0.964)	(1.205)	(0.305)	(0.392)
GDP GROWTH			0.050**		0.052**			0.028		0.040
			(2.145)		(2.217)			(0.974)		(1.238)
COUNTRY SPREAD			-0.000		-0.000			0.000		0.000
			(-1.459)		(-0.223)			(0.390)		(1.186)
Δ HOUSE PRICE			3.616***		2.390***			1.216		-0.152
			(3.600)		(2.773)			(0.942)		(-0.100)
No. of obs.	909	909	909	909	909	521	521	521	521	521
R^2	0.574	0.616	0.635	0.664	0.674	0.628	0.649	0.652	0.687	0.692
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds under different levels of market discipline to test *H3*. The analysis is performed on the entire sample (columns 1–5) and on the subsample of banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10); the ratio of the bank's liquid assets to total assets (*LIQUIDITY*); and the interaction between either *CB USER* or *CB RATIO* and *LIQUIDITY*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. Specifications in columns 1–3 and 6–8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country group by year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

marginal effects are imprecisely estimated for the extensive margin. However, the results in Panel *B* indicate that the marginal effects are significantly negative for banks with liquidity ratios below approximately 0.13 and significantly positive for banks with liquidity ratios above roughly 0.5. Overall, these results support *H4*.

In Table 6, we estimate a modified version of Equation (2), which simultaneously accounts for the interaction between covered bonds and market discipline, and covered bonds and liquidity. As such, it allows us to jointly test *H3* and *H4*. In Tables 4 and 5, we demonstrated that the share of senior unsecured debtholders and the share of liquid assets matter for bank risk. Thus, introducing the effects of liquidity and of monitoring in the same regressions controls for omitted variables and reduces the standard error of the estimates.

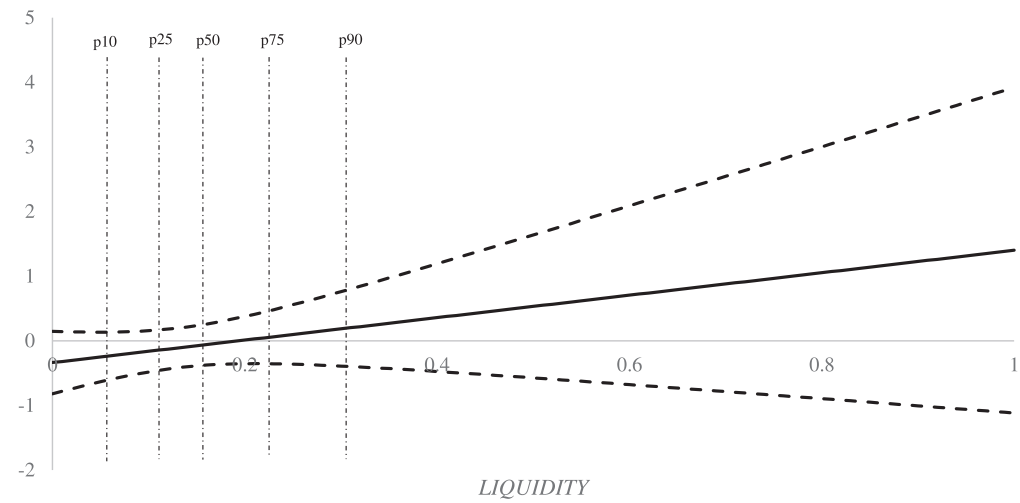
The regressions in Table 6 show negative and statistically significant coefficients for the non-interacted covered bond variables in all specifications except in column 5, where it is marginally significant (T-statistic of -1.66). This confirms our previous findings that asset encumbrance increases risk for firms with the lowest market discipline (in line with *H3*) and liquidity (in line with *H4*). Also consistent with both hypotheses, we find that the interaction terms are always positive and statistically significant for market discipline in all specifications and for liquidity in the intensive margin.

In Fig. 3, we plot the marginal effect of asset encumbrance on bank risk for different levels of liquidity (left-hand side) and market discipline (right-hand side) for both the extensive (Panel *A*) and the intensive margin (Panel *B*). We use the estimates in Table 6, columns 3 and 8, for the graphs. Results are similar to those found in Figs. 1 and 2. However, in this case, the coefficients for the marginal effect of covered bonds on liquidity are precisely estimated for a wide range of values of liquidity and fractions of monitoring bondholders in both the intensive and extensive margins. The results, which are fully consistent with *H3* and *H4*, suggest that the impact of encumbrance on risk is negative for banks with levels of liquidity that are below roughly 30–35% and for banks that have a proportion of unsecured debtholders below approximately 40% of total liabilities. However, for banks with high liquidity buffers and a large proportion of monitoring debtholders, encumbrance has no significant effect on risk. Interestingly, Fig. 3 shows that despite the lack of significance of the coefficients of the interaction term in the extensive margin, there is a range of values of liquidity where the increase in risk is statistically significant.

4.5. Robustness tests

In this section, we explore whether our main results are robust to different measures for asset encumbrance, market discipline and risk. We first address the concern that asset encumbrance might not be precisely measured with covered bonds. For this analysis, we hand-collect a comprehensive measure of asset encumbrance from voluntary disclosures to the EBA, available from 2014, and merge it into our data. This information is available for 58 unique banks in our sample, for a total of 105 bank-year observations for 2014 and 2015. Not surprisingly, we find that the overall encumbered asset ratio is 18% higher than our covered-bond based measure of encumbrance. However, both measures correlate positively, with a pairwise correlation of 0.546 which is statistically significant at the 1% level. This result suggests that our measure of asset encumbrance is a good proxy for the bank's overall asset encum-

Panel *A* . Extensive margin.



Panel *B* . Intensive margin.

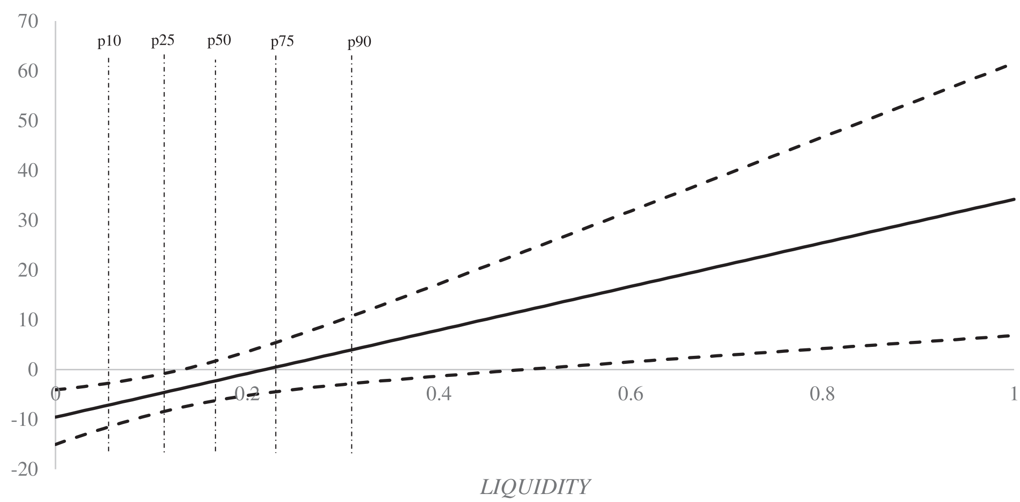


Fig. 2. Marginal effect of covered bond usage on distance to default for different levels of liquidity.
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's liquidity buffers (as measured by *LIQUIDITY*, the ratio of liquid assets to total assets). Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's market discipline. The estimates correspond to those in column 3 of Table 5. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's market discipline. The estimates correspond to those in column 8 of Table 5. Vertical lines correspond to percentiles in the distribution of *LIQUIDITY*.

brance level. In Table IA.3 in the Internet Appendix, we replicate the results in columns 6-10 of Table 6 using this measure; the corresponding marginal effects are contained in Figure IA1.[15] In spite of the significant reduction in the sample size, the results show precisely estimated positive and significant coefficients of the two interaction terms in several specifications. This exercise helps to strengthen the validity of our analysis based on covered bonds to measure asset encumbrance. Importantly, these results also allow us to validate the interpretation of our results as a general feature of asset encumbrance, rather than a particularity of covered bonds.

Next, we analyze whether our results are sensitive to our choice of risk measure. In Table IA.4 in the Internet Appendix, we show the results of the estimations in Table 6 using the ratio of non-performing loans to assets as an alternative measure of bank risk; Figure IA.2 shows the corresponding marginal effects. The figure reveals that even though some of the interaction term coefficients are estimated with less precision than in our main table, the conclusions that we derived from Table 6 are confirmed with this new measure.

We also test whether our results are robust to an alternative measure of market discipline. We use the ratio of total deposits to total liabilities as an alternative proxy for market discipline.[16] Table

[15] We cannot estimate these results in the extensive margin, as we cannot distinguish banks that decided not to voluntarily disclose their asset encumbrance from banks that have zero asset encumbrance and hence do not need to disclose anything to the EBA.

[16] Ideally, banks with low market discipline should be those with a large share of insured depositors. In fact, as insured depositors will get their deposits back regardless of what happens to the bank, they have few incentives to engage in monitoring. However, we cannot distinguish between insured and uninsured depositors in our data. This variable is measured with error, which biases our results against statistical significance. However, to the extent that uninsured depositors believe they have

Table 6
Asset encumbrance, liquidity, market discipline, and bank risk.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CB USER	-2.103***	-1.517***	-1.256**	-0.905*	-0.814					
	(-4.016)	(-2.714)	(-2.329)	(-1.813)	(-1.656)					
CB RATIO						-26.410***	-23.359***	-22.508***	-19.475***	-20.470***
						(-5.163)	(-4.986)	(-5.008)	(-3.856)	(-3.982)
LIQUIDITY	-0.287	0.419	0.654	-0.695	-0.365	-0.813	0.173	0.182	-0.234	-0.671
	(-0.229)	(0.289)	(0.462)	(-0.523)	(-0.265)	(-0.585)	(0.132)	(0.136)	(-0.198)	(-0.556)
SENIOR	-4.356***	-2.263*	-1.689	-2.663**	-2.339*	-5.016***	-3.661**	-3.435**	-4.557***	-4.976***
	(-3.778)	(-1.682)	(-1.331)	(-2.118)	(-1.913)	(-4.230)	(-2.475)	(-2.379)	(-3.480)	(-3.859)
CB × *LIQUIDITY*	2.125	1.767	1.168	0.835	0.644	46.312***	34.016**	32.759**	23.307	21.788
	(1.322)	(1.049)	(0.683)	(0.527)	(0.400)	(2.737)	(2.278)	(2.253)	(1.638)	(1.578)
CB × *SENIOR*	2.827***	2.244**	2.022**	1.530*	1.464*	30.938**	36.299**	35.662**	30.193**	31.003**
	(2.729)	(2.271)	(2.208)	(1.701)	(1.700)	(2.077)	(2.434)	(2.450)	(2.078)	(2.218)
CAPITAL		26.276***	22.776***	23.593***	21.904***		16.672***	16.251***	15.802***	17.078***
		(5.993)	(5.084)	(5.991)	(5.751)		(2.890)	(2.677)	(3.086)	(3.402)
SIZE		-0.164	0.053	-0.231	-0.012		-0.605	-0.506	-0.603	-0.610
		(-0.464)	(0.165)	(-0.686)	(-0.037)		(-1.497)	(-1.180)	(-1.630)	(-1.643)
LOANS		0.572	1.517	-0.361	0.185		0.313	0.588	-1.533	-1.781
		(0.452)	(1.204)	(-0.274)	(0.137)		(0.170)	(0.310)	(-0.759)	(-0.891)
No. of obs.	860	860	860	860	860	506	506	506	506	506
R^2	0.587	0.621	0.638	0.669	0.676	0.653	0.668	0.670	0.707	0.713
Country Controls	N	N	Y	N	Y	N	N	Y	N	Y
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds under different levels of bank liquidity and market discipline. The analysis is performed on the entire sample (columns 1–5) and on the subsample of banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10); the ratio of the bank's liquid assets to its total assets (*LIQUIDITY*); the ratio of the bank's senior liabilities to its total liabilities (*SENIOR*); the interaction between either *CB USER* or *CB RATIO* and *LIQUIDITY*, and the interaction between either *CB USER* or *CB RATIO* and *SENIOR*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. All specifications include bank fixed effects. Specifications in columns 1–3 and 6-8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country group × year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

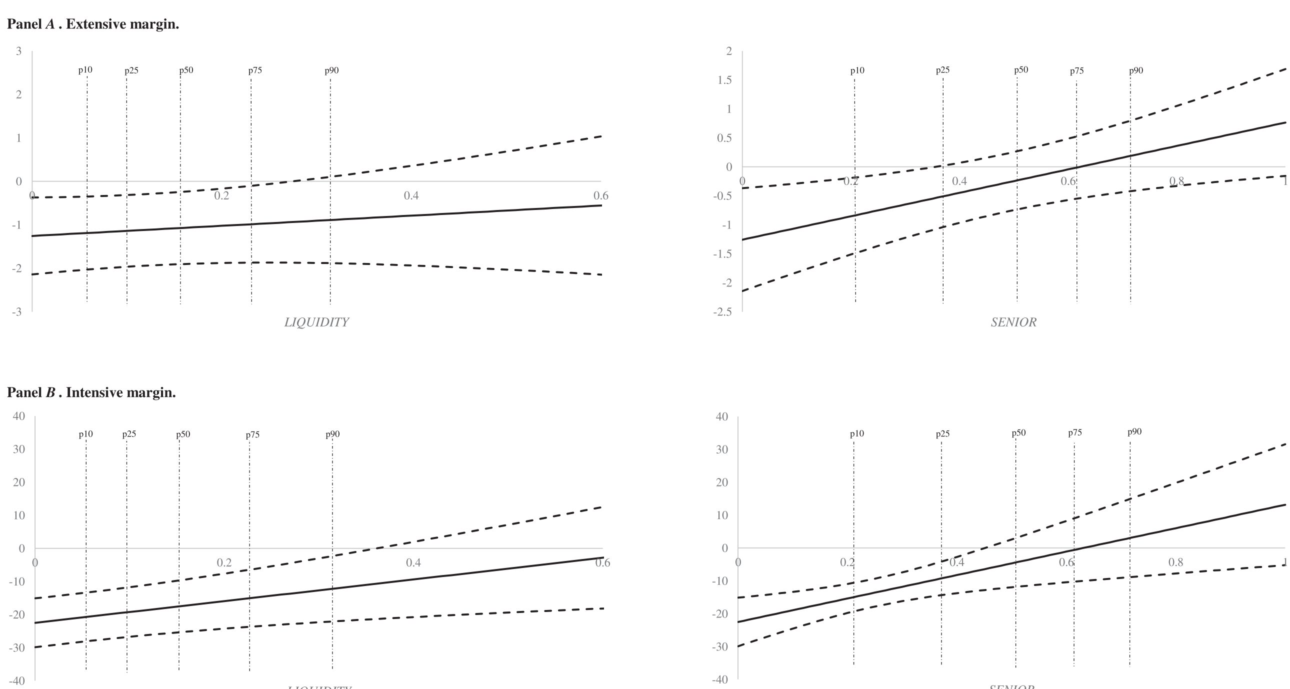


Fig. 3. Marginal effect of covered bond usage on distance to default for different liquidity and market discipline levels.
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's level of liquidity (as measured by *LIQUIDITY*, the ratio of liquid assets to total assets, panels on left-hand side) or the share of senior unsecured liabilities (as measured by *SENIOR*, panels on right-hand side). Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 3 of Table 6. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 8 of Table 6. Vertical lines correspond to percentiles in the distribution of *LIQUIDITY* and *SENIOR*.

IA.5 of the Internet Appendix replicates the results of Table 6 using this measure, and Figure IA.3 contains the marginal effects. The results are in line with *H3* and consistent with those we found in Table 6, with particularly strong effects in the intensive margin.

Lastly, another concern is that our analysis is at the bank holding level, and banks may operate with subsidiaries in several countries. In such instances, country group by time fixed effects and country-level control variables will not capture factors contributing to riskiness in foreign markets. To address this issue, we select a subsample of banks that operate only in their local headquarter country, and repeat the estimations of Table 6 over this subsample. Results, contained in Table IA.6 of the Internet Appendix, are very similar to our previous results.

4.6. Extensions

4.6.1. Asset encumbrance, bank capital, and risk

Using a similar argumentation as in section 2, one might wonder whether the effect of encumbrance on risk could affect banks with different capitalization levels differently. There are two effects that could lead to such a differential response. On the one hand, by securing the assets for the covered bondholders, asset encumbrance could reduce overall monitoring in the bank (and consequently market discipline), which could lead to an increase in the level of risk taking by shareholders. Due to the standard asset substitution and risk shifting mechanisms, incentives to increase risk should be larger for banks that have lower levels of capital relative to well-capitalized banks. On the other hand, consistently with *H3*, an increase in asset encumbrance also reduces the seniority of the unsecured debtholders, increasing their incentives to monitor. Such an increase in the incentives to monitor by unsecured debtholders can be larger for banks perceived ex-ante to be riskier, such as poorly-capitalized banks. As a result of these two opposing forces, the overall effect of asset encumbrance on bank risk could be larger for poorly-capitalized banks than for well-capitalized banks (if shareholders' incentives to increase risk prevails), or it could be smaller (if the unsecured debtholders are able to exert enough market discipline).

We empirically examine if one of these two opposing effects of asset encumbrance prevails, by estimating equation (2) using bank capital to interact with asset encumbrance. Results of these regressions are in Table IA.7 of the Internet Appendix, and show that the interaction term is not statistically significant. This suggests that the two effects with opposing signs cancel each other out.

4.6.2. Asset encumbrance and bank risk during crises

In our hypothesis development leading to *H4*, we argue following the related literature that the effects of asset encumbrance on bank risk for banks with limited liquidity could be amplified by economic downturns. In Table IA.8 of the Internet Appendix, we verify whether these arguments have support in our data by replicating the results in Table 6 over the subsample of observations corresponding to the financial crisis. Results show that this is indeed the case: The coefficients of the interaction term of the covered bond ratio with bank liquidity are larger than their counterparts in Table 6, and become statistically significant. However, this result only holds for the intensive margin, and not for the extensive margin. One plausible explanation is that illiquid unencumbered banks could not access the covered bond market during the crisis precisely due to their greater fragility.

an implicit government guarantee on their deposits, this variable is a good alternative proxy for market discipline measured with precision.

5. Dealing with endogeneity

5.1. Instrumental variables

The estimations in Tables 2 to 6 include bank fixed effects, year fixed effects and, in some specifications, country group by year fixed effects. Thus, the results cannot be explained by unobserved, time-invariant, cross-sectional differences in users and non-users of covered bonds. Moreover, they cannot be explained by an increase in banks' risk that is associated with an increase in the use of covered bonds within the same country group. In addition, our measures of covered bond use are lagged one year, which further mitigates the potential role of reverse causality in explaining our results.

Despite the use of such fixed effects, our estimates could be potentially biased if the use of encumbered securities is most valuable for riskier banks. For example, Bao and Kolasinski (2016) find that non-financial firms resort more to secured debt when their credit quality deteriorates, as it reduces the cost of debt and lowers the incentives of firms to engage in asset substitution. The same could be true for banks. We deal with this issue by adopting an instrumental variables (IV) approach. As an instrument for the use and amount of covered bonds of a given bank, we take the average ratio of outstanding amounts of covered bonds to the total assets of all *other* public and private banks in the same country and year (variable *CB OTHERS*). This instrument should capture the fraction of the variation in the use of covered bonds that is driven by common practices in the country where the bank is headquartered for each year. As such, it should be relevant for explaining the use of covered bonds for a given bank. Table IA.9 in the Internet Appendix contains the results of a first-stage regression estimation where our two main covered bond variables are regressed on this instrument, and it shows that the instrument is indeed relevant, and it is also not weak, as shown by the high values of the Kleibergen-Papp Wald F-statistic.

Importantly, by construction, the instrument accounts for the variation in the use of covered bonds in a given country and year due to unobserved variables, just as a country by year fixed effects approach would control for unobserved factors that are common in a given country and year. In this sense, the IV approach is preferred to the estimations with country group by year fixed effects, as it allows us to control for unobserved factors at the more granular country-year level. The drawback of this approach is its lower efficiency, which is common to all IV estimations.

Crucially, the variable *CB OTHERS* should satisfy the exclusion restriction because the average amount of outstanding covered bonds in other banks in the country should be unrelated to a given bank's level of risk. In fact, similar instruments have been used in related work (see, e.g., Laeven and Levine, 2009). In addition, the instrument considers the use of covered bonds not only by other public banks, but also by the private banks that operate in the same country and year as the focal bank but were excluded from our main estimations due to the lack of information regarding their market risks, enhancing its exogeneity.[17]

Table 7 contains second-stage IV regressions for a simultaneous test of *H3* and *H4* as the one in Table 6, estimated with a two-stages least squares estimator.[18] Columns 1 to 3 contain es-

[17] While the exclusion restriction is by nature impossible to test empirically, in an unreported analysis we perform a comparison of the characteristics of banks with low or high values of the instrument, splitting by the sample median. The standardized differences in all the main bank characteristics used in this analysis, including bank risk, is lower than the 0.25 rule-of-thumb threshold suggested by Imbens and Wooldridge (2009) for comparability.

[18] As is common in applications with interacted variables, we instrument these with the product of the covered bond instrument and the original variable. Table

Table 7
Asset encumbrance, liquidity, market discipline, and bank risk: Instrumental variables estimations.

	(1)	(2)	(3)	(4)	(5)	(6)
CB USER	-17.605***	-14.769*	-6.850			
	(-2.623)	(-1.761)	(-0.888)			
CB RATIO				-40.377**	-37.107**	-34.142*
				(-2.558)	(-2.184)	(-1.730)
LIQUIDITY	-12.052	-10.927	-5.787	-0.319	0.026	0.388
	(-1.114)	(-0.999)	(-0.598)	(-0.138)	(0.012)	(0.148)
SENIOR	-20.004***	-16.557*	-7.067	-8.279***	-7.094**	-5.709
	(-3.461)	(-1.873)	(-0.814)	(-3.622)	(-2.300)	(-1.590)
CB × *LIQUIDITY*	22.918	20.431	16.583	59.308	34.970	22.383
	(0.818)	(0.785)	(0.697)	(1.061)	(0.660)	(0.340)
CB × *SENIOR*	24.300***	20.774*	10.757	49.048	76.214*	86.104**
	(2.701)	(1.785)	(0.937)	(1.344)	(1.879)	(2.259)
CAPITAL		10.551	12.868		12.274	12.367
		(0.860)	(1.557)		(1.406)	(1.370)
SIZE		-0.520	-0.956		-1.812***	-1.515***
		(-0.419)	(-0.638)		(-4.270)	(-3.446)
LOANS		-2.510	0.247		-4.029**	-2.384
		(-1.402)	(0.128)		(-2.522)	(-1.113)
GDP GROWTH			0.029			-0.002
			(1.165)			(-0.081)
COUNTRY SPREAD			-0.000			0.000
			(-0.408)			(0.022)
Δ *HOUSE PRICE*			6.389***			4.282**
			(2.999)			(2.485)
No. of obs.	849	849	849	501	501	501
R^2	0.411	0.129	0.317	0.534	0.577	0.580
Bank FE	Y	Y	Y	Y	Y	Y

This table reports the second-stage coefficient estimates of instrumental variables regressions testing for the impact of outstanding covered bonds on overall bank risk under different levels of bank liquidity and market discipline. The analysis is performed on the entire sample (columns 1–3) and on the subsample of banks with outstanding covered bonds (columns 4–6). The dependent variable is the distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–3) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 4–6); the ratio of the bank's liquid assets to its total assets (*LIQUIDITY*); the ratio of the bank's senior liabilities to its total liabilities (*SENIOR*); the interaction between either CB USER or *CB RATIO* and *LIQUIDITY*, and the interaction between either *CB USER* or *CB RATIO* and *SENIOR*. *CB USER* and *CB RATIO* of bank *i* have been instrumented using the average ratio of outstanding covered bonds of other public and private banks in the same country and year as bank *i*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. All specifications include bank fixed effects. Robust *t*-statistics are clustered at the bank level and are presented in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

timations for the extensive margin, while columns 4 to 6 contain estimations for the intensive margin. The signs of the coefficients estimated with IV are consistent with those of the OLS estimations found in Tables 4 to 6. More specifically, we find significant negative coefficients for the non-interacted terms and positive coefficients for the interaction terms, which are statistically significant for the market-discipline variable *SENIOR*.[19]

For easier interpretation of our results, in Fig. 4 we plot the marginal effects for the covered bond variables corresponding to columns 2 and 5 of Table 7 as a function of the ratio of bank liquidity (left-hand side) and the share of senior unsecured debtholders (right-hand side) for the extensive margin (Panel *A*) and the intensive margin (Panel *B*). The results are similar to those in Fig. 3 but estimated with less precision due to the lower efficiency of the IV estimates. The figure shows that there is a range of liquidity values (lower than 20% of total assets) and senior liabilities (lower than 20% of total liabilities) for which an increase in asset encumbrance in the intensive margin leads to a statistically significant increase in the bank's risk.

5.2. The crisis and increases in covered bond use among risky banks

Another concern that is not fully addressed in the previous section is that our results might be driven by an unobserved time-varying factor that increased banks' expected riskiness and at the same time increased the use of covered bonds for a set of banks *within* a given country group. Indeed, our sample period includes the disruptive period from 2008 to 2012. This period includes the financial crisis and the subsequent European sovereign debt crisis. Consequently, it is characterized by an overall increase in risk among European banks. During this period, the ECB launched several "covered bond purchase programs" to increase banks' incentives to use covered bonds as a funding instrument. These programs were designed to abet banks' access to long-term funding and to alleviate the lack of confidence between banks that led to a halt in interbank market activity at the height of the financial crisis. However, these programs were introduced precisely at the

IA.10 contains the first-stage estimations. Panel A contains the nine first-stage regressions for the extensive margin (corresponding to columns 1-3 of Table 7), and Panel B contains the first-stage regressions for the intensive margin (columns 4-6 of Table 7). Given that two of the instrumented variables are the interaction of the covered bond variable with bank liquidity and seniority respectively, we expect a positive coefficient for variable *CB OTHERS, LIQUIDITY* (or *SENIOR*, respectively), or the interaction between these two variables. We find indeed a positive coefficient for at least one of these terms.

[19] There are two plausible explanations for the larger IV coefficients relative to their OLS counterparts. The first one is an OLS underestimation of the effect of covered bonds on bank risk due to simultaneity bias. The second is that IVs estimate the Local Average Treatment Effects (LATE), i.e., the effect on the "compliers" (intuitively, these are banks that increase or decrease their own use of covered bonds in line with the country's trend), while OLS estimates the average treatment effect (ATE) on all individuals. Given that covered bonds are measured with a lag, the second explanation is most likely to drive the differences.

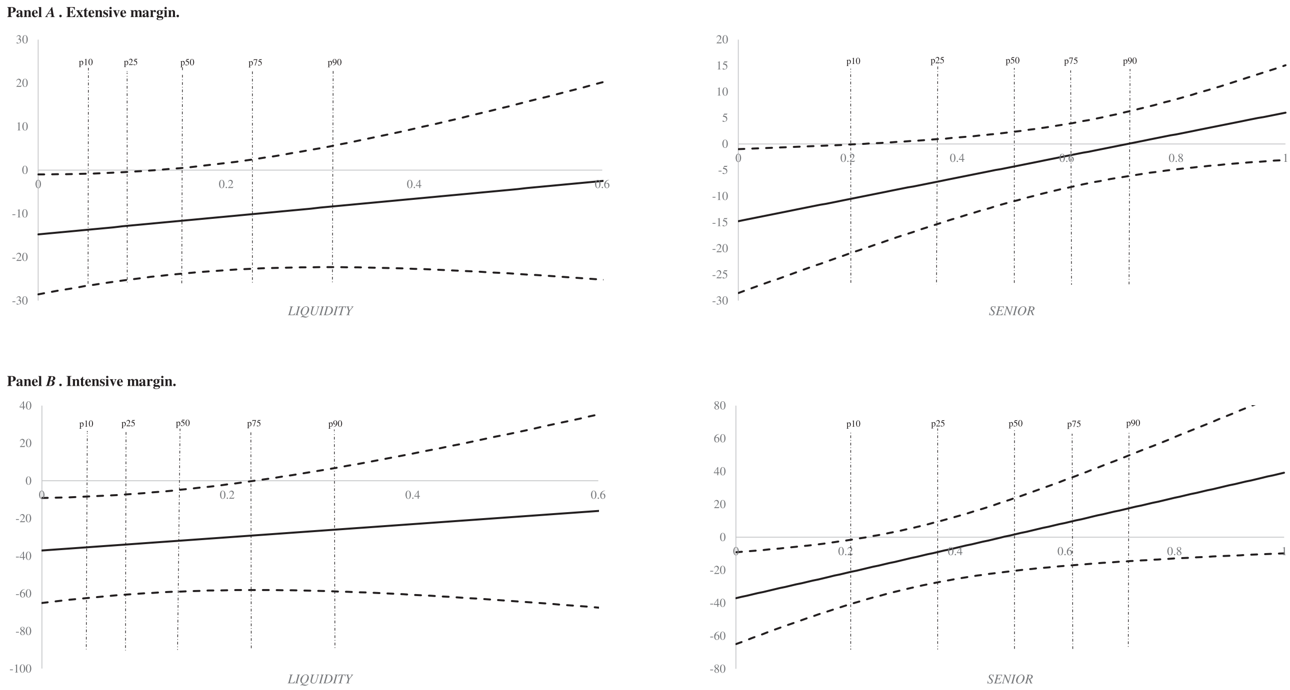


Fig. 4. IV estimates of the marginal effect of covered bond usage on distance to default for different liquidity and market discipline levels.
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the instrumental variables estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's level of liquidity (as measured by *LIQUIDITY*, the ratio of liquid assets to total assets, panels on left-hand side) or the share of senior unsecured liabilities (as measured by *SENIOR*, panels on right-hand side). Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 2 of Table 7. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 5 of Table 7. Vertical lines correspond to percentiles in the distribution of *LIQUIDITY* and *SENIOR*.

time of increased risk in the European banking sector. This leads to well-founded inverse causality concerns regarding our previous results (i.e., that the banks that were more affected by the crisis within a given country group were those that increased their use of covered bonds the most).

We address this problem by estimating the coefficients for the non-crisis years. If the driver of the results in Tables 4 to 6 is greater use of covered bonds by the banks that were more affected by the crisis, we should find no effect for the coefficients of the *CB* variables in the non-crisis years. The results of this analysis are reported in Table 8, and a graph of the marginal effects corresponding to specifications 3 and 8 is presented in Fig. 5. The results do not qualitatively differ from those in Tables 4 to 6, which suggests that reverse causality between risk and the use of covered bonds plays a limited role due to a heterogeneous effect of the crisis on the sample banks within each country group. Interestingly, the insignificant coefficients of the interaction term *CB* × *LIQUIDITY* contrast with the significant ones during the crisis years (Table IA.8). This finding suggests, in line with Ahnert et al. (2019), that bank liquidity plays a crucial role during periods of financial stress.

5.3. Decrease in covered bond use among safer banks

A related concern is that our results may be driven by banks that simultaneously reduced their reliance on covered bonds as a funding instrument and were significantly less affected by the 2008–2012 crisis. In particular, the use of covered bonds fell significantly during our sample period in Germany, which was less affected by the crisis than the other countries in our sample (see Panel *B* of Table IA.2 in the Internet Appendix). This was most likely the result of the removal of government guarantees for all liabilities of the German Landesbanken in 2005, which led to a notable reduction in the issuance of bonds, including covered bonds (Fischer et al., 2014). To the extent that banks in Germany were less affected by the financial crisis than the rest of the banks in our sample, we would expect a simultaneous decrease in the use of covered bonds and a reduction in the risk of these banks, which might lead to the results observed in Tables 4 to 6.

To address this concern, we repeat the estimations in Table 6 after excluding German banks from the sample. The results are presented in Table 9, while the marginal effects corresponding to specifications 3 and 8 are illustrated in Fig. 6. This robustness check largely confirms our previous findings and suggest that these inverse causality concerns do not play a significant role in our main estimations.

Overall, the tests in Tables 7 to 9, with the accompanying estimates of marginal effects contained in Figs. 4 to 6, imply that our main findings are not driven by reverse causality or by an omitted variable that simultaneously affects the use of covered bonds and increases banks' risk. Thus, we conclude with the observation that the impact of asset encumbrance on bank risk can be affected by unsecured senior debtholders and liquidity buffers.

6. Conclusion

This study investigates whether and to which extent asset encumbrance, or the ring-fencing of certain assets for protected debtholders, affects bank risk. Using a sample of publicly listed European banks, we start our analysis by showing that an increase in

Table 8
Asset encumbrance, liquidity, market discipline, and bank risk: Estimations excluding crisis years (2008–2012).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CB USER	-2.353***	-1.720***	-1.104**	-0.901	-0.718					
	(-3.562)	(-2.709)	(-2.094)	(-1.425)	(-1.352)					
CB RATIO						-31.974***	-27.849***	-29.455***	-24.188**	-28.798***
						(-3.039)	(-3.024)	(-3.416)	(-2.546)	(-3.104)
LIQUIDITY	-0.170	1.217	0.078	-0.435	-0.506	-1.288	0.264	-0.008	0.201	-1.009
	(-0.113)	(0.728)	(0.050)	(-0.263)	(-0.317)	(-0.759)	(0.151)	(-0.005)	(0.141)	(-0.659)
SENIOR	-4.808***	-2.374	-0.928	-3.003*	-1.578	-4.928**	-3.786	-4.355*	-5.195**	-6.369***
	(-3.436)	(-1.498)	(-0.712)	(-1.954)	(-1.171)	(-2.594)	(-1.407)	(-1.678)	(-2.121)	(-2.753)
CB × *LIQUIDITY*	0.955	0.639	-0.040	0.153	-0.439	40.414*	25.303	25.867	23.951	25.925
	(0.453)	(0.312)	(-0.019)	(0.076)	(-0.210)	(1.682)	(1.398)	(1.467)	(1.245)	(1.394)
CB × *SENIOR*	3.882***	3.309***	2.591**	1.914	1.946*	45.359**	49.815**	52.259**	36.701	41.847**
	(2.715)	(2.858)	(2.401)	(1.554)	(1.767)	(2.032)	(2.255)	(2.480)	(1.598)	(2.104)
CAPITAL		29.615***	30.340***	26.208***	28.201***		13.253*	17.796**	16.046**	19.773***
		(4.635)	(5.275)	(4.781)	(5.682)		(1.749)	(2.491)	(2.538)	(3.340)
SIZE		0.011	0.378	0.046	0.403		-0.883	-1.039*	-0.906*	-1.207**
		(0.027)	(1.060)	(0.116)	(1.128)		(-1.499)	(-1.730)	(-1.880)	(-2.550)
LOANS		1.999	2.663	0.756	1.723		1.636	0.933	-0.657	-1.174
		(1.230)	(1.653)	(0.491)	(1.080)		(0.539)	(0.282)	(-0.206)	(-0.385)
No. of obs.	492	492	492	492	492	274	274	274	274	274
R^2	0.577	0.615	0.665	0.670	0.698	0.641	0.659	0.678	0.708	0.733
Country controls	N	N	Y	N	Y	N	N	Y	N	Y
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds under different levels of bank liquidity and market discipline. The analysis is performed on the subsample of non-crises years (columns 1–5) and on the corresponding subsample of banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10); the ratio of the bank's liquid assets to its total assets (*LIQUIDITY*); the ratio of the bank's senior liabilities to its total liabilities (*SENIOR*); the interaction between either *CB USER* or *CB RATIO* and *LIQUIDITY;* and the interaction between either *CB USER* or *CB RATIO* and *SENIOR*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. Specifications in columns 3, 5, 8, and 10 contain country controls (*GDP GROWTH*, *COUNTRY SPREAD*, and Δ *HOUSE PRICE*). All specifications include bank fixed effects. Specifications in columns 1–3 and 6-8 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country group × year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

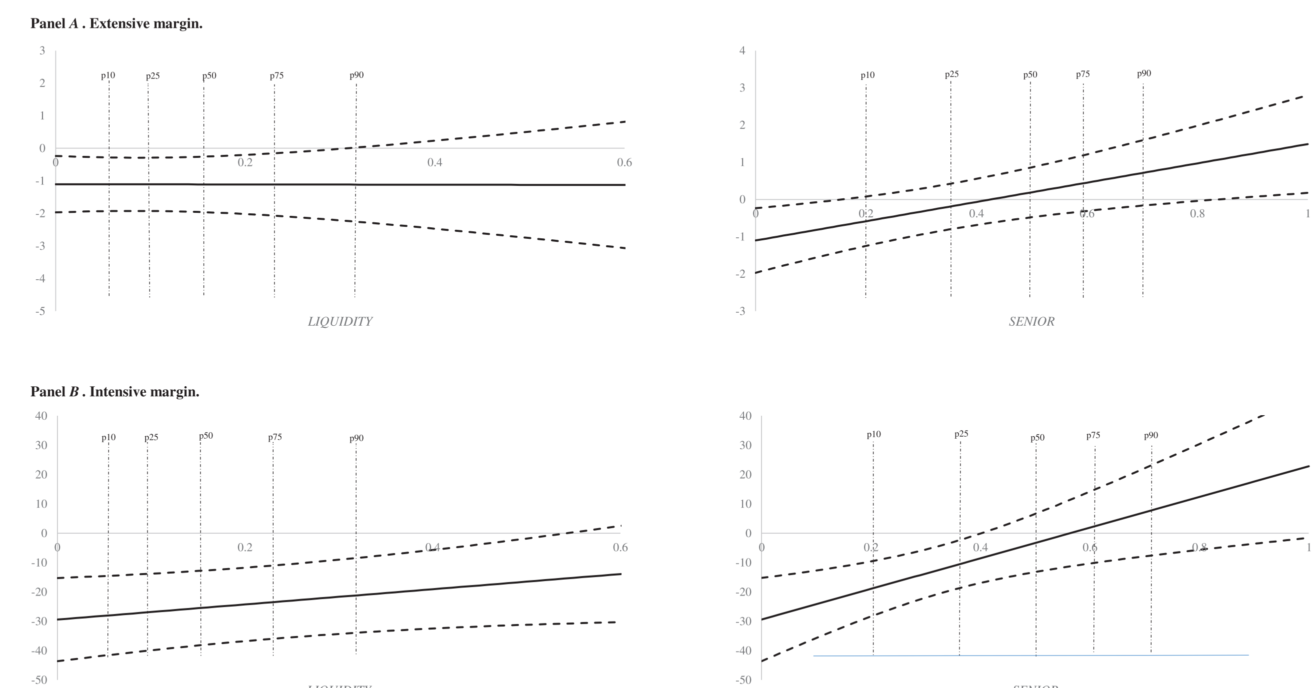


Fig. 5. Estimates of the marginal effect of covered bond usage on distance to default for different liquidity and market discipline levels: Estimations excluding crisis years (2008–2012).
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's level of liquidity (as measured by *LIQUIDITY*, the ratio of liquid assets to total assets, panels on left-hand side) or the share of senior unsecured liabilities (as measured by *SENIOR*, panels on right-hand side) for the subsample of non-crises years. Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 3 of Table 8. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 8 of Table 8. Vertical lines correspond to percentiles in the distribution of *LIQUIDITY* and *SENIOR.*

Table 9
Asset encumbrance, liquidity, market discipline, and bank funding risk: Estimations excluding German banks.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CB USER	-2.731***	-2.046***	-1.845***	-1.361**	-1.312**					
	(-4.220)	(-2.997)	(-2.877)	(-2.281)	(-2.250)					
CB RATIO						-28.326***	-23.193***	-22.311***	-21.523***	-22.418***
						(-4.792)	(-4.530)	(-4.440)	(-4.224)	(-4.158)
LIQUIDITY	-0.750	-0.726	-0.536	-1.806	-1.488	-1.138	-0.529	-0.573	-0.810	-1.229
	(-0.477)	(-0.408)	(-0.308)	(-1.118)	(-0.888)	(-0.694)	(-0.361)	(-0.376)	(-0.643)	(-0.964)
SENIOR	-5.638***	-3.162**	-2.575*	-3.548***	-3.207**	-5.235***	-3.387**	-3.134**	-4.307***	-4.758***
	(-4.263)	(-2.104)	(-1.839)	(-2.636)	(-2.444)	(-3.812)	(-2.135)	(-2.003)	(-2.747)	(-3.007)
CB × *LIQUIDITY*	2.889	2.934	2.368	2.043	1.856	71.573***	62.135***	61.601**	53.980**	51.035**
	(1.445)	(1.369)	(1.109)	(1.032)	(0.931)	(2.865)	(2.682)	(2.638)	(2.189)	(2.034)
CB × *SENIOR*	3.597***	2.795**	2.663**	2.008*	2.000**	26.729	29.737*	28.919*	28.664*	28.892*
	(3.060)	(2.437)	(2.555)	(1.964)	(2.049)	(1.613)	(1.764)	(1.758)	(1.741)	(1.778)
CAPITAL		28.070***	24.454***	24.721***	23.089***		17.556***	16.982***	15.996***	17.676***
		(6.846)	(5.864)	(6.404)	(6.090)		(3.058)	(2.814)	(2.933)	(3.306)
SIZE		-0.428	-0.122	-0.493	-0.225		-0.583	-0.456	-0.577	-0.605
		(-1.039)	(-0.328)	(-1.287)	(-0.603)		(-1.209)	(-0.862)	(-1.298)	(-1.302)
LOANS		-0.548	0.594	-0.801	-0.118		-0.127	0.196	-0.531	-0.717
		(-0.390)	(0.416)	(-0.548)	(-0.077)		(-0.064)	(0.097)	(-0.231)	(-0.313)
No. of obs.	736	736	736	736	736	427	427	427	427	427
R^2	0.569	0.608	0.626	0.650	0.656	0.662	0.676	0.677	0.706	0.713
Country Controls	N	N	Y	N	Y	N	N	Y	N	Y
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	N	N	Y	Y	Y	N	N
Country group × Year FE	N	N	N	Y	Y	N	N	N	Y	Y

This table reports the coefficient estimates of an OLS regression of overall bank risk on the use of covered bonds under different levels of bank liquidity. The analysis is performed on the subsample of all non-German banks (columns 1–5) and on the subsample of such banks with outstanding covered bonds (columns 6–10). The dependent variable is the bank's distance to default (*DTD*). The main explanatory variables are: a dummy that identifies the banks with outstanding covered bonds (*CB USER*; columns 1–5) or the ratio of the amount of the bank's total outstanding covered bonds to its total assets (*CB RATIO*; columns 6–10); the ratio of the bank's liquid assets to its total assets (*LIQUIDITY*); the ratio of the bank's senior liabilities to its total liabilities (*SENIOR*); the interaction between either *CB USER* or *CB RATIO* and *LIQUIDITY;* and the interaction between either *CB USER* or *CB RATIO* and *SENIOR*. Control variables are defined in Table 1. All variables are winsorized at the 1% and 99% levels. All bank-level explanatory variables are lagged one period. Specifications in columns 3, 5, 8, and 10 contain country controls (*GDP GROWTH, COUNTRY SPREAD*, and △ *HOUSE PRICE*). All specifications include bank fixed effects. Specifications in columns 1–3 and 8–9 contain year fixed effects. Specifications in columns 4–5 and 9–10 contain country group × year fixed effects. Robust *t*-statistics are clustered at the bank level and are shown in parentheses.
***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

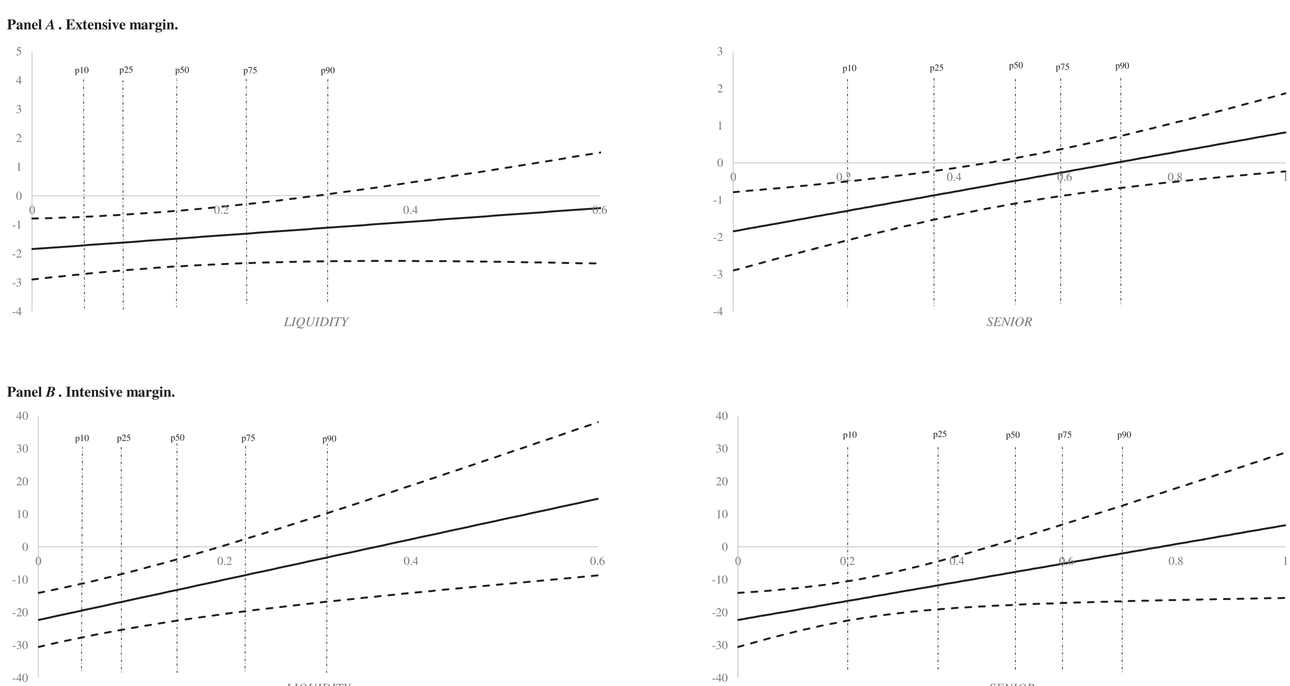


Fig. 6. Marginal effect of covered bond usage on distance to default for different liquidity and market discipline levels: Estimations excluding German Banks.
This figure contains the point estimates (solid line) and 90% confidence intervals (dashed lines) for the estimates of the marginal effect of covered bonds on banks' distance to default (*DTD*) according to the bank's level of liquidity (as measured by *LIQUIDITY*, the ratio of liquid assets to total assets, panels on left-hand side) or the share of senior unsecured liabilities (as measured by *SENIOR*, panels on right-hand side) on the subsample of all non-German banks. Panel *A* illustrates the marginal effect of using covered bonds (*CB USER*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 3 of Table 9. Panel *B* illustrates the marginal effect of the covered bond ratio (*CB RATIO*) on a bank's distance to default as a function of the bank's liquidity ratio. The estimates correspond to those in column 8 of Table 9. Vertical lines correspond to percentiles in the distribution of *LIQUIDITY* and *SENIOR.*

asset encumbrance does not significantly affect the risk for the average bank in our sample. However, we demonstrate that asset encumbrance significantly affects the risk associated with unsecured debt by effectively reducing the seniority of these claims. Specifically, the price of insurance against unsecured debtholders' default risk rises as asset encumbrance increases. This suggests that holders of unsecured debt should have more incentives to monitor the risk associated with a bank's assets following a rise in asset encumbrance, as they should desire to reduce their expected losses. We therefore propose that the effect of asset encumbrance on risk can be explained by taking into account the market discipline effect exerted by the bank's existing creditors.

In line with our conjecture, we find that banks with a smaller proportion of monitoring debtholders experience an increase in risk following an increase in asset encumbrance. Symmetrically, banks with larger proportions of monitoring debtholders are able to mitigate the increase in risk arising from asset encumbrance. We also test whether asset encumbrance can lead to higher funding fragility by reducing the amount of unencumbered collateral that can be liquidated to service early withdrawals. In this regard, we show that the relation between bank risk and asset encumbrance can be affected by the amount of liquidity on a bank's balance sheet. In other words, an increase in encumbrance leads to greater instability only if banks do not have enough liquidity buffers to service early withdrawals.

To the best of our knowledge, our finding that the proportion of existing debtholders whose priority is affected by the asset encumbrance affects the relation between encumbrance and bank risk is new. Our analysis suggests that policymakers should assess the benefits of encumbrance relative to the potential costs of an increase in risk given the structure of not only the bank's liquid assets of the bank but also its liabilities, especially the intensity of monitoring by existing stakeholders.

In summary, the issuance of covered bonds has ambiguous effects in terms of financial stability. On the one hand, covered bonds represent a more conservative asset class, which becomes particularly appealing during times of financial turbulence. They can also provide banks with an additional source of funding during times of market turmoil. On the other hand, covered bonds may have undesired effects in terms of risk-taking and fragility.[20] Our study shows that whether the positive or negative effects of encumbrance on risk prevail largely depends on the structure of the banks' assets (liquidity) and liabilities (existing unsecured debtholders).

Policymakers have acknowledged the importance of the structure of banks' assets and liabilities for the effect of encumbrance on risk. Indeed, regulators in some jurisdictions have adopted a cap on encumbered assets that depends on the bank's assets (e.g., a 4% ratio in Canada; an 8% ratio in Australia and Belgium), the bank's liabilities (e.g., a 4% ratio in the United States), or both the bank's assets and capitalization (e.g., in Italy). The results of our study suggest that such limits might be more effective and better calibrated if banks' liquidity levels and their proportions of monitoring debtholders are also accounted for in the calculations. Indeed, various regulators, such as the ECB and the Bank of England Prudential Regulation Authority, have recently pointed to the importance of the interconnection between the encumbrance of assets and the makeup of liquid asset buffers in banks' Internal Liquidity Adequacy Assessment Processes (ILAAP).

Our results are based on a unique, albeit partial, measure of asset encumbrance—the amount of outstanding covered bonds issued by a bank. As such, our estimates should be interpreted as a lower bound for the effect of overall asset encumbrance on risk. In fact, the evidence that even a partial asset encumbrance measure has material effects underpins the recommendation of the Financial Stability Board (2013) that banks should provide detailed asset encumbrance information in their annual accounts. This recommendation was echoed in the EBA's introduction of new guidelines for disclosing asset encumbrance in 2014, the adoption of the European Covered Bond Council's common Harmonised Transparency Template in 2016, and the inclusion of transparency provisions in the proposal for the EU Covered Bonds Directive of March 2018.

Improved disclosure of asset encumbrance could not only help investors price debt more precisely, but also enable banks to maintain an appropriate balance between secured and unsecured debt. It would also ensure that such price valuations and decisions are based on a truthful representation of the asset encumbrance level rather than the uncertainty surrounding it.

Credit author statement

All authors have contributed to the manuscript equally.

Data Availability

Data will be made available on request.

Funding

A previous version of the paper was circulated under the title "Covered Bonds, Asset Encumbrance and Bank Risk: Evidence from the European Banking Industry". For their helpful comments, we would like to thank two anonymous referee, the Editor (Carol Alexander), Diana Bonfim, Yann Braouezec, Paolo Colla, Filippo De Marco, Jerry Drives, John Duca, Jens Forssbaeck, Stephen Gates, Mattia Girotti, Carl Larsson, Philipp Lentner, Francesco Manaresi, Christophe Perignon, Andrea Resti, Alex Sclip, Daniel Streitz, Natalja von Westernhagen, Stefano Zedda, and participants at the 2017 AFFI Conference in Valence, the 2017 FMA European Conference in Lisbon, the World Finance Conference in Cagliari, the 2017 FMA Conference in Boston, the 2018 PANORisk conference in Nantes, the 2019 Swiss Winter Conference on Financial Intermediation in Lenzerheide, and the 2021 French Finance Association Conference in Nantes (online). We are also thankful to Maurice Kees for providing excellent research assistance. Garcia-Appendini gratefully acknowledges financial support from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program, ERC ADG 2016 GA, grant agreement No. 740272: lending.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jbankfin.2022.106705.

[20] In the European Union, the Bank Recovery and Resolution Directive (BRRD) might have worsened these effects. As they are typically exempt from bail-in in case of the resolution of a bank under the Bank Recovery and Resolution Directive and the Single Resolution Mechanism Regulation (SRMR), covered bonds benefit from enhanced protection against financial distress of the issuer, as a resolution is unlikely to result in the direct enforcement of the recourse against the cover pool. In fact, for a covered bondholder to suffer a loss, a bank would need to run into financial distress and the bail-in of senior unsecured creditors should be insufficient to resolve the bank crisis. The government would then have to decline to bail out the bank given the failure of the bail-in. Even if the bank defaulted on its bonds, the covered bondholder would gain ownership over the high-quality over-collateralized cover pool, thus requiring a default of the issuer of these assets for the covered bond to experience a loss.

Appendix

Variable definitions.

Variable	Definition	Source
CB USER	Dummy = 1 if the bank has outstanding covered bonds, 0 otherwise.	DCM Analytics and BankFocus
CB RATIO	Ratio of the total amount of outstanding covered bonds to total assets.	DCM Analytics and BankFocus
DTD	Distance to default.*	CRI database
NPL RATIO	Ratio of non-performing loans to total loans.	BankFocus
SPREAD	Average daily price—over the entire observed year—of the five-year** senior-debt CDS contract denominated in EUR with a "modified-modified" (MM) restructuring clause.*** In order to mitigate the impact of missing and stale spreads, we follow Schneider et al. (2010) in requiring that the overall percentage of missing or stale spreads must not exceed 15% per bank-year and that the length of the longest series of consecutive missing/stale spreads must be 10 days or less.****	Markit
SENIOR	Ratio of senior liabilities (assets net of equity, deposits, subordinated borrowings, and outstanding covered bonds) to total liabilities net of equity.	BankFocus
DEPOSITS	Ratio of total deposits to total liabilities.	BankFocus
LIQUIDITY	Ratio of liquid assets (cash and due from banks, trading securities and at fair value through income, loans and advances to banks, reverse repos and cash collaterals) to total assets.	BankFocus
CAPITAL	Ratio of equity to total assets.	BankFocus
SIZE	Natural logarithm of total assets.	BankFocus
LOANS	Ratio of total loans to total assets.	BankFocus
GDP GROWTH	Country-level GDP yearly growth rate.	World Bank
COUNTRY SPREAD	Average daily price—over the entire observed year—of the five-year country sovereign debt CDS contract denominated in USD. In order to mitigate the impact of missing and stale spreads, the overall percentage of missing or stale spreads must not exceed 15% per bank-year and the length of the longest series of consecutive missing/stale spreads must be 10 days or less.	Markit
Δ HOUSE PRICE	Country-level yearly change in real house prices.	OECD
CB OTHERS	Ratio of covered bonds to total assets of the other public and private banks in the same country and year.	DCM Analytics and BankFocus

All currencies have been converted in EUR.

All variables, except GDP GROWTH, COUNTRY SPREAD, and ΔHOUSE PRICE have been winsorized at the 1st and 99th percentiles to mitigate the effect of extreme values.

*A detailed description of the distance to default calculation method used by CRI is presented in section IA.2 of the Internet Appendix.

**Five years is the maturity of most liquid CDSs.

***Most European default swaps are transacted according to the "modified-modified" restructuring clause.

****This problem is alleviated by the fact that CDS quotes are retrieved from Markit Group Ltd, which collects indicative CDS premia from a broad range of dealers and aggregates them into a composite value, thus ensuring a reasonably continuous and accurate time series.

References

Ahnert, T., Anand, K., Gai, P., Chapman, J., 2019. Asset encumbrance, bank funding and financial fragility. Rev. Financ. Stud. 32 (6), 2422–2455.

Banal-Estañol, A., Benito, E., Khametshin, D., Wei, J. (2021). "Asset encumbrance and bank risk: theory and first evidence from public disclosures in Europe", Working Papers 2131, Banco de Espana.

Settlements, Bank for International, 2013. Asset encumbrance, financial reform and the demand for collateral assets. Committ. Glob. Financ. Syst. Paper 49.

Bao, J., Kolasinski, A.C., 2016. Why do firms issue secured debt? mimeo.

Beirne, J., Dalitz, L., Ejsing, J., Grothe, M., Manganelli, S., Monar, F., Sahel, B., Sušec, M., Tapking, J., Vong, T., 2011. The impact of the Eurosystem's covered bond purchase Programme on the primary and secondary markets. Eur. Central Bank Occasion. Paper Ser. 122/January.

Birchler, U., 2000. Bankruptcy priority for bank deposits. Rev. Financ. Stud. 13 (3), 813–840.

Bliss, R.R., Flannery, M.J., 2002. Market discipline in the governance of U.S. Bank holding companies: monitoring vs. Influencing. Rev. Finance 6, 361 –39.

Brambor, T., Clark, W.R., Golder, M., 2006. Understanding Interaction Models: Improving Empirical Analyses. Polit. Anal. 14 (1), 63–82.

Calomiris, C.W., Kahn, C.M., 1991. The role of demandable debt in structuring optimal banking arrangements. Am. Econ. Rev. 497–513.

Calomiris, C.W., 1999. Building an incentive-compatible safety net. J. Bank. Financ. 23, 1499–1519.

Camba-Mendez, G., Carbo-Valverde, S., Rodriguez-Palenzuela, D., 2014. Financial reputation, market interventions and debt issuance by banks: a truncated two–part model approach. European Central Bank Working Paper 1741/2014.

Covitz, D., Liang, N., Suarez, G.A., 2013. The evolution of a financial crisis: collapse of the asset-backed commercial paper market. J. Finance 68 (3), 815–848.

Danisewicz, P, McGowan, D., Onali, E., Schaeck, K., 2018. Debt priority structure, market discipline, and bank conduct. Rev. Financ. Stud. 31 (1), 4493–4555.

European Banking Authority (2012). EBA report on risks and vulnerabilities of the European banking system, July.

European Banking Authority (2013). EBA report on EU covered bond frameworks and capital treatment, December.

European Banking Authority (2019). EBA report on asset encumbrance, August. Available at https://eba.europa.eu/.

European Covered Bond Council (2019), Covered bonds: a global perspective. ECBC global issues working group, March. Available at https://hypo.org/ecbc/.

Fama, E., 1978. The effects of a Firm's investment and financing decisions on the welfare of its stockholders. Am. Econ. Rev. 68, 272–284.

Financial Stability Board, 2013. Enhanced Disclosure Task Force Report.

Fischer, M., Hainz, Ch., Rocholl, J., Steffen, S., 2014. ESMT Working Paper, p. 14.

Gai, P., Haldane, A.G., Kapadia, S., Nelson, B.D., 2013. Bank funding and financial stability. In: Heath, A., Lilley, M., Manning, M. (Eds.), Liquidity and Funding Markets: Proceedings of the Reserve Bank of Australia Annual Conference, pp. 237–252.

Galai, D., Masulis, R.W., 1976. The option pricing model and the risk factor of stock. J. Financ. Econ. 3 (1/2), 53–81.

Gorton, G., Metrick, A., 2011. Securitized banking and the run on the Repo. J. Financ. Econ. 104 (3), 425–451.

Gropp, R., Vesala, J., Vulpes, G., 2006. Equity and bond market signals as leading indicators of bank fragility. J. Money Credit Bank. 38 (2), 399–428.

Helberg, S., Lindset, S., 2014. How do asset encumbrance and debt regulations affect bank capital and bond risk? J. Bank. Financ. 44, 39–54.

Imbens, G., Wooldridge, J., 2009. Recent developments in the econometrics of program evaluation. J. Econ. Lit. 47 (1), 5–86.

International Monetary Fund, 2013. Global Financial Stability Report.

Ippolito, F., Peydró, J.-L., Polo, A., Sette, E., 2016. Double bank runs and liquidity risk management. J. Financ. Econ. 122 (1), 135–154.

Jensen, M., Meckling, W., 1976. Theory of the firm: managerial behavior, agency costs and ownership structure. J. Financ. Econ. 3 (4), 305–360.

Laeven, L., Levine, R., 2009. Bank governance, regulation and risk taking. J. Financ. Econ. 93 (2), 259–275.

Martinez Peria, M.S, Schmukler, S.L., 2001. Do depositors punish banks for bad behavior? Market discipline, deposit insurance, and banking crises. J. Finance 56 (3), 1029–1051.

Schneider, P., Sögner, L., Veza, T., 2010. The economic role of jumps and recovery rates in the market for corporate default risk. J. Financ. Quant. Anal. 45, 1517–1547.

Stultz, R.M., Johnson, H., 1985. An analysis of secured debt. J. Financ. Econ. 14 (4), 501–521.