Asset Encumbrance and Bank Risk: Theory and First Evidence from Public Disclosures in Europe*

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Abstract

Asset encumbrance refers to the existence of restrictions to a bank's ability to transfer or realize its assets. We provide a theoretical model that highlights the implications of asset encumbrance for funding risks. We show that the effect of encumbrance depends on the costs of transferring encumbered assets to the secured creditors upon default. With low costs of unencumbering bank's assets, encumbrance is negatively associated with bank credit risks as secured funding minimizes bank's exposure to liquidity shocks. When the unencumbering costs are high, encumbrance can exacerbate liquidity risks due to structural subordination effect and, hence, can be positively associated with bank credit risk premiums. We use a novel dataset on the levels of asset encumbrance of European banks and provide empirical evidence supporting the predictions of the model. Our empirical results point to the existence of a negative association between CDS premia and asset encumbrance. This relationship is further amplified by liquidity of banks' balance sheets and stability of their funding. Capital and credit quality of bank assets, on the contrary, do not exhibit strong mediation role between asset encumbrance and bank funding risk.

Keywords: asset encumbrance, collateral, bank risk, credit default swaps

JEL classification: G01, G21, G28

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1 Introduction

As of June 2011, Dexia, a Franco-Belgian bank, reported a strong Tier 1 capital ratio of 11.4%. Out of the 91 institutions analysed in the European Banking Authority (EBA) stress tests, Dexia came joint 12th, with a forecast Core Tier 1 capital ratio of 10.4% under the adverse stress scenario. From a liquidity standpoint, the bank had built up a buffer of €88bn in liquid securities, and its short-term ratings had been reaffirmed as investment grade by the main credit rating agencies. But just three months later, in October 2011, Dexia was partly nationalised by the Belgian and French governments. Several commentators highlighted the high levels of "encumbered" assets as the key factor precipitating its move into government arms.[1]

Asset encumbrance refers to the existence of bank balance sheet assets being subject to arrangements that restrict the bank's ability to transfer or realise them. Assets become encumbered when they are used as collateral to raise funding, for example in repurchase agreements (repos), or in other collateralised transactions such as asset-backed securitisations, covered bonds, or derivatives. In the particular case of Dexia, more than €66bn of its €88bn buffer securities were encumbered through different secured funding arrangements, particularly with the European Central Bank (ECB), and were therefore unavailable for obtaining emergency funding.

Policymakers are acting decisively in order to address what some consider to be excessive levels of asset encumbrance. Some jurisdictions have introduced limits on the level of encumbrance (Australia, New Zealand) or ceilings on the amount of secured funding or covered bonds (Canada, US), while others have incorporated encumbrance levels in deposit insurance premiums (Canada). Several authors have proposed linking capital requirements to the banks' asset encumbrance levels or establishing further limits to asset encumbrance as a back-stop (Juks (2012), IMF (2013), Helberg and Lindset (2014)). As part of the Basel III regulatory package, the Net Stable Funding Ratio (NSFR), which will introduce additional minimum liquidity requirements, heavily penalises asset encumbrance by requiring substantial amounts of stable funding. In Europe, regulatory reporting and disclosure requirements have been introduced and all institutions are required to incorporate asset encumbrance within their risk management frameworks. The Dutch National Bank has even committed to "keeping encumbrance

[1] See Dexia 2Q & 1H 2011 Results and Business Highlights Presentation, 4 August 2011, and Financial Times, "Bank collateral drying up in rush for security", October 2011. More recently, in June 2017, Banco Popular was put into resolution by the European Single Supervisory Mechanism (SSM) and was acquired by Banco Santander for a symbolic amount of €1. Yet, as of year-end 2016, the Spanish bank Banco Popular reported a Tier 1 capital ratio of 12.3% and had passed the EBA stress tests undertaken in 2016 with a solid margin. However, nearly 40% of its total balance sheet assets were encumbered as of December 2016.

to a minimum" (De Nederlandsche Bank (2016)).

Such policy actions stem from a negative perception of asset encumbrance. First, increasing asset encumbrance reduces the amount of unencumbered assets that a bank can use to meet sudden liquidity demands and the pool of assets that become available to unsecured creditors under insolvency, an effect coined as "structural subordination". If unsecured creditors reflect the risks of asset encumbrance into their required returns, institutions would face higher overall funding costs. As stated by Dr Joachim Nigel, a former member of the executive board of the Deutsche Bundesbank in a speech at the 2013 European Supervisor Education Conference on the future of European financial supervision: "Higher asset encumbrance has an impact on unsecured bank creditors. The more bank assets are used for secured funding, the less remain to secure investors in unsecured instruments in the case of insolvency. They will price in a risk premium for this form of bank funding."

This paper argues that asset encumbrance may also bring in important benefits. Collateral also provides safety, potentially reducing the bank's overall cost of funds and liquidity risks. We first present a theoretical model exploring the trade-offs of asset encumbrance and their implications for liquidity risk, and banks' risk premia. In our model, asset encumbrance has two opposing effects on liquidity risk. First, as the level of asset encumbrance increases, the bank will have fewer unencumbered assets available to meet creditors demands in case of stress — this is the *structural subordination* effect of asset encumbrance. On the other hand, with higher levels of encumbrance, the bank has fewer liabilities subject to a run and, hence, lower liquidity risk — this is the *stable funding* effect of asset encumbrance. Overall, which effect dominates depends crucially on the costs of transferring bank's assets to the secured investors upon default. These costs may represent legal costs and transaction costs (as specified, for instance, in ICMA's Global Master Repurchase Agreement), or additional inefficiencies stemming from weaker monitoring incentives of secured investors, or higher price impact in fire sales of collateral (Duffie and Skeel (2012)).

We show that the stable funding effect dominates the adverse effect of structural subordination when these costs are relatively low. Indeed, in this case, secured finance reduces default risk because unencumbering bank's assets in case of default leaves plenty of liquidity to the unsecured creditors. On the contrary, when the encumbrance costs are high, the amount of liquidity available after paying back the debts to the secured creditors is diminished. This effect is priced in by the unsecured investors *ex-ante* who require higher return on their investments. In this case, the structural subordination effect dominates the stable financing effect and secured funding increases default risk.

This trade-off generates two distinct predictions on the relationship between encumbrance levels and bank risk. In the case of low encumbrance costs, banks increase the level of asset encumbrance as much as possible, as secured funding is not only cheaper but it also reduces default risk. At the same time, unsecured debt holders would require lower premia to compensate for bank's default risk and recovery rates. Instead, in the case of high unencumbering costs, banks face a trade-off, as secured funding is cheaper but it increases default risk. As a result, we may have banks with higher available collateral to choose higher levels of asset encumbrance despite having higher liquidity risk. So, the relationship between asset encumbrance and the cost of unsecured funding may be positive.

We test these predictions and investigate, in the absence of data on the availability of bank collateral limits, the association of asset encumbrance and credit risk spreads. We built a novel dataset using information provided in the asset encumbrance disclosures published for the first time throughout 2015 by European banks, following a set of harmonised definitions provided by the EBA (EBA (2014)). In a cross-section of banks, we find that institutions with higher encumbrance levels tend to have lower CDS spreads — i.e. bank risk seems to be negatively associated with asset encumbrance. We also find that some variables play a mediating role in the relationship between asset encumbrance and bank risk. For banks with highly illiquid balance sheets, correlation of asset encumbrance with bank risk is less pronounced and, in extreme cases, is positive. Bank capital and quality of its assets, on the contrary, do not seem to introduce heterogeneity in the encumbrance-risk link. These findings imply that regulators need to be cautious when assessing asset encumbrance levels and leaping to across-the-board conclusions about its effects.

We contribute to a growing literature studying asset encumbrance and bank financial instability. In Ahnert et al. (2018), a bank's amount of unsecured debt is fixed and the bank can expand profitable investment through secured funding, which leads to greater asset encumbrance. However, with greater asset encumbrance, fewer unencumbered assets are available to meet unsecured debt withdrawals, thereby exacerbating bank's liquidity risk when recovery rates are low. As a consequence, Ahnert et al. (2018) predict that bank's asset encumbrance level is positively correlated with the premium of unsecured debt. In our model, on the contrary, banks can use secured financing to replace unsecured funding. This generates the stable funding effect of asset encumbrance. Thus, we predict that bank's asset encumbrance level can be negatively correlated with the premium of unsecured debt when the costs associated with unencumbering bank's assets are low. This result also differs from Matta and Perotti (2015), where more secured debt results in more liquidity risk and, therefore, unsecured debt bears more risk requiring a higher promised yield.

Our paper is related with the literature on secured debt and more generally firms' debt structure choices. Theoretically, the possible explanations of the use of secured debt include mitigating agency conflicts between shareholders and creditors (C. W. Smith and Warner (1979), Stulz and Johnson (1985)), addressing the information asymmetries between the lender and borrower (Chan and Thakor (1987), Berger and Udell (1990), Thakor and Udell (1991)), or use as a commitment device (Donaldson, Gromb, and Piacentino (2017)). Unlike these papers, our paper focus on bank's funding structure and emphasizes a different friction of collateralised borrowing: the interaction between secured borrowing and bank's unsecured creditors and liquidity risk, which is banking specific.

Empirically, Julio, Kim, and Weisbach (2007) find that the vast majority of public debt issues are unsecured, while Nini, D. C. Smith, and Sufi (2009) document that 65 percent of a large sample of private credit agreements between 1996 and 2005 were secured. In the context of banking, Di Filippo, Ranaldo, and Wrampelmeyer (2016) find that that banks with higher credit risk are able to offset a reduction of unsecured borrowing with secured loans, consistent with theories of lender moral hazard. Unlike Di Filippo, Ranaldo, and Wrampelmeyer (2016), we find that better banks may use more secured debt. Besides, our paper focuses on the relationship between asset encumbrance level and the premium of unsecured debt holders. Therefore, our paper can explicitly tackle the issue of structural subordination missing in Di Filippo, Ranaldo, and Wrampelmeyer (2016).

The rest of the paper is organized as follows. Section 2 describes the theoretical framework. Section 3 identifies the effects of an exogenous level of asset encumbrance on bank default risk. Section 4 examines the optimal choices of asset encumbrance as well as the predicted relationships between the optimally chosen levels of asset encumbrance and the endogenous levels of bank funding costs. Section 5 provides empirical evidence supporting model predictions. Section 6 concludes. Appendix A provides the proofs of the mathematical results whereas Appendix B describes the sources of asset encumbrance in the data.

2 Theoretical Framework

We now present a simple model of a bank to understand the effects of asset encumbrance, as well as the resulting observed relationships between the optimally chosen levels of asset encumbrance and the endogenous levels of bank funding costs we find in the data.

A risk-neutral bank has access to a profitable project that needs one unit of cash at $t = 0$.

The bank's project generates a random return $\theta \geq 0$ at $t = 1$ and a fixed return $k < 1$ at $t = 2$. The random payoff θ is distributed on the range $[0, \bar{\theta}]$ with a continuous cumulative distribution function F and a non-decreasing hazard ratio. As $k < 1$ and θ can be zero, the bank will be subject to insolvency risk. The bank is protected by limited liability.

At $t = 0$, the bank has no cash at hand, so it needs to raise funds from a competitive credit market offering fairly-priced long-term demandable debt.[2] That is, creditors can withdraw their money at $t = 1$ before the debt matures at $t = 2$. To meet creditor withdrawals, the bank can use, in addition to θ, the proceeds from selling part of the fixed second-period returns k prematurely. The bank can sell its assets at $t = 1$ only at a fire-sale discount: the per-unit price at $t = 1$ is $\phi < 1$.[3] The bank fails if the amount of funds withdrawn at $t = 1$ exceeds its liquid assets. Thus, as in Allen and Gale (1994), the bank is subject to liquidity risk.

The bank raises funding by issuing secured or unsecured debt, so as to maximize the bank's expected profits at $t = 0$. There are two types of creditors. Some are risk neutral but demand a minimum expected gross return of $1 + \gamma$, with $\gamma > 0$. The others are infinitely risk averse, and willing to lend only if debt is absolutely safe, but they demand a minimum return of just 1.[4] Since infinitely risk averse investors demand a lower expected return, it is optimal for the bank to raise (safe) secured funding from this group of investors, and (risky) unsecured debt from the risk neutral investors. This setup captures a major advantage of secure funding: it is perceived to carry lower roll-over risks and is generally cheaper than equivalent unsecured funding. In what follows, we refer to γ as risk premium or funding gains.

Denote by s the funds raised through secured debt to the risk-averse investors, and by $1 - s$ those raised trough unsecured debt to the risk-neutral investors. To make sure risk-averse investors are repaid fully and unconditionally, the bank needs to pledge enough assets. The bank can use the project's payoff k at $t = 2$. The bank's return θ at $t = 1$, instead, cannot be pledged because it is random. Hence, from now on, we refer to k as the available collateral of the bank.

The maximum amount of secured funding available to the bank at $t = 0$ is ϕk. Indeed, for each unit of secured funding, the bank needs to pledge $1/\phi > 1$ units of the collateral k, where $1/\phi - 1$ reflects the haircut. Since secured debt is required to be absolutely safe, the level of

[2] Calomiris and Kahn (1991), Diamond and Dybvig (1983) and Diamond and Rajan (2001) provide microfoundations for demandable debt. For instance, in Calomiris and Kahn (1991) and Diamond and Rajan (2001), demandable debt act as an instrument to prevent opportunistic behavior by the bank (managers).

[3] Equivalently, at $t = 1$, there is a bond market where the bank can sell, at a price ϕ, riskless bonds which promise one unit of cash at $t = 2$. Since the project's payoff at $t = 2$ is k, the bank can sell up to k riskless bonds. Freixas and Rochet (2008), for instance, use the same setup.

[4] Gennaioli, Shleifer, and Vishny (2012), Stein (2012) and Caballero and Farhi (2013) use similar modeling assumptions. See Gorton, Lewellen, and Metrick (2012) and Krishnamurthy and Vissing-Jorgensen (2012) for empirical evidence.

haircut is determined by the price of the collateral in the market, so that the bank can sell the collateral and recover $(1/\phi)\phi = 1$ for each unit of secured funding at $t = 1$.

The assets pledged to secured debt holders as collateral are encumbered, so they cannot be used at $t = 1$ to meet unsecured debt holders' withdrawals. In the event of a "bank run", secured debt holders can seize the encumbered assets to meet their claim s. Because of full collateral protection, they have no incentive to withdraw money in the interim period (i.e. to run the bank). In case of bank failure, the bank distributes any of the remaining proceeds from selling the long-term assets prematurely $k\phi - s$, along with θ, on a pro-rata basis to the unsecured investors.

Encumbrance of bank's assets, however, may also be costly. Duffie and Skeel (2012) mention several reasons why secured funding can result in additional costs, including weaker incentives of creditors to monitor the bank, or higher price impact of collateral fire sales, or stronger incentives of a distressed bank to postpone filing for bankruptcy. Encumbrance costs may also represent legal or transaction costs of transferring assets from the defaulting bank to the secured creditors. To capture these ideas in a parsimonious way, we introduce proportional costs $c \geq 0$ of (un-)encumbering bank's assets, so that the bank incurs additional losses cs in case secured creditors need to seize their collateral. As we will show below, a high level of c is necessary to generate a positive relationship between optimal asset encumbrance and the interest rate on the unsecured debt.[5]

The timing of the model is illustrated in Figure 1. For simplicity, we assume that the bank's project is profitable (in expected terms) even if all the long-term assets are liquidated at $t = 1$ and the bank finances the project entirely through unsecured debt.

[Figure 1]

Our model includes several departures from the Modigliani and Miller framework. As it is standard in the banking literature, in the environment of costly asset liquidation, coordination failure and contract incompleteness may give rise to bank runs. Furthermore, the wedge in the required return of risk-neutral and risk-averse investors makes secured debt an attractive cheaper source of funds for the bank. But encumbered assets give rise to additional liquidation costs, thus reducing the amount of liquidity available to the unsecured investors *ex-post* and increasing bank risk and its total debt obligations *ex-ante*. We turn to the analysis of these effects in the next section.

[5]The assumption that encumbrance costs are incurred by the bank only in case of default is important. If, in addition, the bank was to pay c out of its profits in case of survival, the model would not deliver positive cross-sectional relationship between the unsecured interest rate and optimal encumbrance ratios. In other words, to be able to match observed empirical patterns one should assume that encumbrance is more costly for a defaulting bank than for a surviving one.

3 Effects of asset encumbrance on bank risk

This section identifies the effects of an exogenous level of secured funding s on the bank's risk. Since secured debt is absolutely safe, the face value per unit of secured debt is equal to 1, which is the minimum return demanded by infinitely risk averse investors. We treat, in first subsection, the face value of a unit of unsecured debt, which we denote by D, as exogenously given and identify the trade-off between structural subordination and stable funding. Thereafter we endogenize D, taking into account that the risk-neutral investors demand a minimum return of $1+\gamma$, and identify the key drivers of the balance of this trade-off.

3.1 Structural subordination vs. stable funding

The bank is exposed to insolvency risk. The bank is insolvent at $t=1$ if and only if the total value of bank's assets is inferior to the total amount of debt obligations:

$$\theta + k < s + (1-s)D.$$

As $k<1$, θ can be zero, and $s+(1-s)D>1$ (as $D \geq 1+\gamma$), there exists a critical solvency return $\underline{\underline{\theta}}$ such that the bank is insolvent if and only if:

$$\theta < \underline{\underline{\theta}}(s) \equiv s + (1-s)D - k. \tag{1}$$

In case the realization of θ is low, unsecured debt holders withdraw their money, thus provoking a (fundamental) bank run.

The bank is not only exposed to insolvency risk but also exposed to liquidity risk. Despite being solvent, the bank may suffer a bank run at $t=1$ if the unsecured investors' demands are superior to the bank's available liquidity. To meet withdrawals, the bank can use its $t=1$ proceeds θ as well as proceeds from the sale of long-term assets, net of the amount recovered by secured creditors, $k\phi - s$, and the costs of unencumbering assets, cs. Hence, the bank may suffer a run if

$$\theta + [k\phi - s(1+c)] < (1-s)D.$$

Rearranging, there exists a critical liquidity return $\underline{\theta}$, such that the bank is illiquid in case all unsecured investors withdraw if and only if:

$$\theta < \underline{\theta}(s) \equiv (1-s)D - [k\phi - s(1+c)]. \tag{2}$$

The range of θ can be split into three regions.[6] If $\theta < \underline{\underline{\theta}}$, the bank is insolvent. If $\underline{\underline{\theta}} < \theta < \underline{\theta}$, the bank is solvent but possibly illiquid. If $\theta > \underline{\theta}$, the bank is solvent and liquid. The intermediate region $\underline{\underline{\theta}} < \theta < \underline{\theta}$ spans multiple equilibria. In one of them, all unsecured debt holders withdraw and the bank fails. In another equilibrium, all unsecured debt holders choose not to withdraw and the bank survives. For simplicity, we assume that the bad equilibrium prevails, so that the bank fails if it is solvent but possibly illiquid, because of the unsecured investors' self-fulfilling concern that all the other unsecured debt holders withdraw.[7] Bank's default risk $\underline{\theta}$ is composed of solvency and liquidity risk, determined by $\underline{\underline{\theta}}$ and $\underline{\theta} - \underline{\underline{\theta}}$, respectively. As $\theta \sim F(\theta)$, the bank fails at $t = 1$ with probability $F(\underline{\theta})$ so that bank's default probability increases in $\underline{\theta}$. Note also, that liquidity risk defined as $\underline{\theta} - \underline{\underline{\theta}} = k(1-\phi) + sc$ is non-decreasing in secured funding and does not depend on encumbrance only if the latter is costless.

Notice that an increase in the level of secured funding, s, has two effects on bank's default risk, $\underline{\theta}$. On the one hand, as s increases $(1-s)D$ decreases, which implies that the bank needs less liquidity to face a potential liquidity shock at $t = 1$. This is the *stable funding effect* of secured financing. On the other hand, as s increases, $k\phi - s(1+c)$ decreases, which implies that the amount of net unencumbered assets available to the unsecured debt holders is lower. This is the *structural subordination effect* of secured funding. As we show next, the balance between the two effects crucially depends on the benefits of using secured funding γ and its associated costs c.

3.2 Costs and benefits of asset encumbrance

The face value of the unsecured debt D is determined by the break-even condition:

$$(1-s)(1+\gamma) = \int_0^{\underline{\theta}(s)} (\theta + k\phi - s(1+c))\,\mathrm{d}F + \int_{\underline{\theta}(s)}^{\bar{\theta}} (1-s)D(s)\,\mathrm{d}F. \tag{3}$$

The first term in the right hand side is the unsecured debt holders' expected return in the case of a bank run: unsecured debt holders share, on a pro-rata basis, the realized return at $t = 1$, θ, as well as all the value value of the encumbered assets, $k\phi - s(1+c)$. The second term in the right hand side is the unsecured debt holder's expected return when they are fully paid. The left

[6] Simple algebra shows that $\underline{\underline{\theta}} \leq \underline{\theta}$, with the inequality being strict if $\phi < 1$ and/or $c > 0$.

[7] If the good equilibrium were to be chosen, bank's liquidity risk will disappear. In this case, only solvency risk would be relevant for the bank. Our results would still hold, nevertheless, if we were to allow (more generally) for an (exogenous) positive probability of failure. In principle, we could also use the global games approach of Goldstein and Pauzner (2005), to select a unique equilibrium, Ahnert et al. (2018) does. We work with an exogenously chosen equilibrium for tractability.

hand side is the opportunity cost of the unsecured debt holders' funding.

Combining (2) and (3), we get the following Proposition:

Proposition 1 *If the costs of unencumbering assets c are lower (higher) than the risk premium γ, bank risk $\underline{\theta}$ is decreasing (increasing) in the level of secured funding s.*

This result is intuitive. In the extreme case of $c = 0$, nothing is lost when unencumbering assets, and since secured creditors do not have incentives to run, increasing the share of secured finance lowers default risk. More generally, if encumbrance does not impose significant liquidation costs on the bank ($c < \gamma$), the amount of liquidity left after recovering the collateral in the case of a bank run is relatively large. In this case, by exploiting the stability of secured debt, the bank need less cash $\underline{\theta}$ to meet the withdrawals of the unsecured investors at $t = 1$: the stable funding effect dominates the one of structural subordination. If, on the contrary, the bank loses a significant portion of its value when recovering the encumbered assets ($c > \gamma$), the amount of liquidity left to the unsecured investors in case of a bank run is small. Hence, for higher values of secured funding s, the bank is required to have more liquidity $\underline{\theta}$ to compensate the outflow of unsecured funds at $t = 1$: the structural subordination effect dominates the one of stable funding.

4 Optimal asset encumbrance and bank risk

We now examine the bank's optimal choices of asset encumbrance, as well as the predicted relationships between the optimally chosen levels of asset encumbrance and the endogenous levels of bank funding costs for different value of available collateral k. Indeed, the cross-sectional relationship between asset encumbrance and bank credit risk is, in reality, driven by the imperfectly observed level of collateral availability. Even though the amount of total assets $(\theta + k)$ may be observable, it is difficult to perfectly separate θ from k using balance sheet data. The comparative statics of the model's results with respect to k helps to understand this relationship. We also study the effects of the different levels of fire-sale prices ϕ to understand the heterogeneity of the relationship between asset encumbrance and bank credit risk.

The expected profits of the bank at $t = 0$ are given by:

$$\Pi = \int_{\underline{\theta}(s)}^{\bar{\theta}} (\theta + k - [s + (1-s)D(s)]\, \mathrm{d}F \tag{4}$$

Indeed, when $\theta < \underline{\theta}$, the banks fails due to a bank run at $t = 1$ and the bank (insiders) get 0. When $\theta > \underline{\theta}$, the bank survives and the payoff of the bank's assets is $\theta + k$. At $t = 2$ the bank pays s to secured debt holders and $(1-s)D$ to unsecured investors. Clearly, Π depends on $\underline{\theta}$ and D, which depend, in turn, on s, as shown in (2) and (3), respectively.

Simple algebra shows that, substituting (2) and (3) into (4), we get that:

$$\frac{\mathrm{d}\Pi}{\mathrm{d}s} = \gamma - cF(\underline{\theta}(s)) - [\underline{\theta}(s) - \underline{\underline{\theta}}(s)]\frac{\mathrm{d}F}{\mathrm{d}s}(\underline{\theta}(s)). \tag{5}$$

A marginal increase in s benefits the bank by allowing it to save γ on each additional unit of secured funding. The second term states that, for a fixed endogenous probability of bank failure, the additional unit of secured finance comes at a cost of losing c in unencumbering bank's assets upon bank run. The last term describes the effect of encumbrance coming from a change in the probability of bank run associated with a marginal shift in secured debt. As we show in the previous section, secured funding can both decrease or increase bank risk, and the direction of this effect crucially depends both on the encumbrance costs c and the funding benefits γ.

4.1 Low encumbrance costs relative to the risk-premium

When the cost of unencumbering bank assets c is low ($c < \gamma$), secured funding affects bank's expected profits positively, in two ways. First, since secured funding is a cheaper source of finance, relative to the costs it has, higher asset encumbrance reduces bank's overall funding cost: conditional on success, the bank receives larger residual payoffs (first two terms in (5)). Second, since $c < \gamma$, asset encumbrance reduces bank's liquidity risk (third term in (5)). Thus, the bank should set the level of secured funding as high as possible.

Proposition 2 *If the costs of unencumbering assets c are lower than the risk premium γ, the bank's profits are strictly increasing in the level of secured funding s, which implies that the optimal level of secured funding for the bank is $s^* = k\phi$.*

We next determine the optimal level of secured funding, as well as the resulting face value of unsecured debt D, for different values of k.

Corollary 1 *If the costs of unencumbering assets c are sufficiently low, as the amount of available collateral k increases, (i) the level of secured funding s^* increases and (ii) the level of unsecured funding cost D^* decreases.*

A bank with more available collateral is able to raise larger amounts of secured finance. As we have shown before, if $c < \gamma$, secured funding reduces bank's liquidity risk. Therefore, the liquidity risk of bank failure decreases in asset encumbrance, and unsecured debt holders demand a lower interest rate to compensate for the risk of bank failure.

This subsection shows, in sum, that in a cross-section of banks with an endogenously chosen level of asset encumbrance, bank's unsecured funding cost D is predicted to be negatively correlated with bank's level of asset encumbrance s when the costs of transferring bank's assets to secured creditors are not too high.

4.2 High encumbrance costs relative to the risk premium

Consider next the case when the cost of transferring bank's assets to its creditors are relatively high ($c > \gamma$). From Proposition 1 we know that in this case bank's risk is increasing in the level of secured funding. In this case the bank may opt not to use its full collateral capacity. In terms of the FOC condition implied by (5), the bank balances the positive effects of secured funding γ with its unambiguously negative consequences for default risk (a higher expected losses induced by encumbrance $cF(\underline{\theta})$, and a marginal increase in the default probability $\frac{\mathrm{d}F}{\mathrm{d}s}(\underline{\theta})$). The effect that dominates depends on the level of encumbrance costs c:

Proposition 3 *If the costs of unencumbering assets c are higher than the risk premium γ, there exist $\underline{c}$ and $\bar{c}$, such that $\gamma < \underline{c} < \bar{c}$ and*

(i) bank profits are strictly increasing in the level of secured funding s, so that the optimal level of secured funding is $s^* = k\phi$ if $\gamma < c < \underline{c}$.

(ii) bank profits exhibit an inverted U-shaped form in the level of secured funding s, so that the optimal level of secured funding is interior, $s^* \in (0, k\phi)$ if $\underline{c} < c < \bar{c}$,

(iii) bank profits are strictly decreasing in the level of secured funding s, so that the optimal level of secured funding is $s^* = 0$ if $c > \bar{c}$

We now show that the relationship between s^* and D^* identified in Corollary 1 can be reversed if the costs of encumbrance are high, $c > \gamma$. Figure 2 plots, in the three panels, (i) the liquidity and solvency risk thresholds, (ii) the optimal level of encumbrance, and (iii) the unsecured interest rate with respect to k. We assume that $\theta = \bar{\theta} - l$ and l has a truncated exponential distribution on $[0, \bar{\theta}]$, with $\bar{\theta} = 1.25$ (so that in expectation θ is about 0.75), $\phi = 0.85$, $c = 0.035$, and $\gamma = 0.015$. We solve the model for k ranging from 0.4 to 0.9.

[Figure 2]

The first panel illustrates that, in equilibrium, the bank with low levels of collateral k need a high level of the asset payoff $\underline{\theta}$ to prevent unsecured creditors from running the bank. As shown in the second panel, funding risks increases even further by issuing secured debt. The bank is better off with a zero level of encumbrance; hence, $s^* = 0$. With higher levels of collateral k, the bank finds it optimal to take on more liquidity risk ($\underline{\theta}$ net of the fundamental solvency threshold $\underline{\underline{\theta}}$), even though this increases the required face value of debt D issued to the unsecured investors. In this case, the bank chooses an interior level of secured funding $s^* < k\phi$. With even higher levels of k, the bank chooses to use full collateral capacity $s^* = k\phi$ as in Proposition 2. Faced with the limit on amount of secured funding that it can attract, the bank can not further increase its liquidity risk $\underline{\theta} - \underline{\underline{\theta}}$. Hence, in this region, the unsecured interest rated D is non-increasing.

This example, and in particular the intermediate case (ii) of the Proposition 3, highlights that bank's asset encumbrance may be positively related to the unsecured interest rate. Contrary to the result of the Corollary 1, banks that face medium costs of assets encumbrance are predicted to exhibit positive correlation between encumbrance ratios and credit risk premiums.

Corollary 2 *If the costs of unencumbering encumbered assets c are high, as the amount of available collateral k increases, (i) the level of secured funding s^* may be increasing and (ii) the level of unsecured funding cost D^* may also be increasing.*

We now illustrate the role of fire-sale prices in the relationship between asset encumbrance and bank funding risk. Figure 3 plots the unsecured funding costs as well as the optimal level of asset encumbrance for two levels of collateral prices: $\phi = 0.95$ and $\phi = 0.75$ (maintaining the other parameters as before).

[Figure 3]

Notice that with a lower liquidation price ϕ, the bank opts for non-zero levels of secured funding s^* at higher levels of available collateral k. This result is intuitive: lower liquidation prices leave less liquidity in the bank in the case of a bank run; hence, only banks with relatively high levels of collateral can afford taking on additional liquidity risk in their funding structure.

One can also conclude that, if at $t = 1$ banks face different levels of collateral prices ϕ, they may exhibit different equilibrium relationships between encumbrance and credit risk premiums in the same range of collateral levels. There exists a range of collateral k such that the relationship is negative if liquidation prices are high (upper panel), and positive when liquidation prices are low (lower panel). This conclusion provides a theoretical basis for a heterogeneous relationship between encumbrance and credit risk premiums that we find in the data.

This subsection shows, in sum, that in a cross-section of banks with an endogenously chosen level of asset encumbrance, bank's unsecured funding costs may be positively correlated with bank's level of asset encumbrance s when the costs of transferring bank's assets to secured creditors are high. The level of collateral price may mediate in the relationship between encumbrance and credit risk premiums.

We now turn to the empirical analysis of the relationship between asset encumbrance and credit risk premiums of banks.

5 Empirical evidence

In this section, we provide empirical evidence supporting the theoretical model described above. Namely, we run a set of regressions aimed to capture the association between the observable levels of asset encumbrance and bank credit risk. We further analyze heterogeneity of this relationship related to bank characteristics.

5.1 Data and Descriptive Statistics

To implement the regression analysis, we extract data from the risk disclosures of banks, including information on encumbered assets, unencumbered assets, off-balance sheet (OBS) collateral received and available for encumbrance, OBS collateral received and re-used and matching liabilities (the liabilities or obligations that give rise to encumbered assets). The baseline cross-sectional analysis is performed on the bank data as of year-end 2014. We complement the disclosure data with data on total assets and equity extracted from Bankscope to compute the asset encumbrance ratios for each institution.

Our main dependent variable in the multivariate regressions is a measure of bank risk represented by banks' average (log of) daily CDS spreads in 2015. CDS spreads are widely considered to be a good indicator of bank risk and can be a proxy for bank unsecured funding costs (see Babihuga and Spaltro (2014); Beau et al. (2014 Q4)). We use implied rather than market-based spreads because only the largest global institutions are involved in CDS issuance. For most banks, Fitch Solutions determines the implied spreads on a daily basis using a proprietary model that includes, as inputs, banks' financial fundamental information, distance-to-default information derived from the equity market, and other market variables. In line with the existing literature, we focus on five-year senior spreads since these contracts account for 85% of the market and are highly liquid. The data on implied CDS levels in 2015 is provided by Fitch Solutions and extracted from Bankscope. We keep only those banks in the sample that have at least 20 daily observations of CDS spreads in 2015.

Computing asset encumbrance measures at the bank level is not straightforward since accounting data provides limited information to infer the amount of banks' encumbered assets, unencumbered assets and matching liabilities. Accounting statements are accompanied by disclosures which try to shed light on the amount of assets that are collateralising transactions but, as noted by the EBA: "existing disclosures in International Financial Reporting Standards (IFRS) may convey certain situations of encumbrance but fail to provide a comprehensive view on the phenomenon" (EBA (2014)). For this reason, the EBA introduced new guidelines in 2014 proposing the requirement to disclose asset encumbrance reporting templates. EBA guidelines do not constitute a regulatory requirement and, although most did, not all of the European institutions disclosed such information.

Furthermore, there is currently no consensus as to how asset encumbrance shall be measured and different measures have been proposed. We focus on the value of encumbered assets normalized by bank's total assets as our main measure of asset encumbrance. We also use other key ratios employed by policymakers in the analysis of encumbrance. Hence, the asset encumbrance ratios capture the amount of encumbered assets as a proportion of total assets:

- The ratio of *encumbered assets to total assets*, which captures the overall proportion of balance sheet assets that have been encumbered. This ratio has been used by the Bank of England and the European Systemic Risk Board (ESRB) to undertake analysis of the UK and European banking sectors respectively (ESRB (2013), Beau et al. (2014 Q4)). We denote it as AE.

- The ratio of *encumbered assets and other collateral received and re-used to total assets and total collateral received*, which captures the overall proportion of encumbered balance sheet assets as well as off-balance sheet collateral. This ratio is used by the EBA to undertake their risk assessment of the European banking system and to apply more comprehensive regulatory reporting requirements (EBA (2016)). We denote this ratio as AE^+.

The third ratio focuses instead on unencumbered assets:

- The ratio of *unsecured liabilities to unencumbered assets* (ULUA), which captures the unsecured creditor's claims as a proportion of assets which are not subject to collateral agreements. This ratio was highlighted by the Bank of International Settlements' Committee on the Global Financial System (CGFS (2013)) as the preferred measure of asset encumbrance.

We report all the encumbrance measures in percentage points. The computation of each ratio is illustrated in figure 4.

[Figure 4]

A significant part of banks discloses composition of encumbered assets, in particular, in the part of encumbrance of debt securities and other assets. In a few cases when the sum of encumbered assets exceeds the corresponding total values, we treat the former as an absolute measure of encumbered assets. Similarly, when the sum of the components of unencumbered assets exceeds the reported total, we set the latter to be equal to the corresponding sum. The vast majority of such cases seem to be driven by rounding errors rather than systematic under-reporting.

Reporting of matching liabilities used in the calculation of ULUA is of lower quality. That is, about 14% of banks in our sample do not disclose the value of matching liabilities. For these banks we impute the values of matching liabilities normalized by the total liabilities from the corresponding median values of banks of similar business model and size category (as defined in Table 2). We further winsorize the ULUA ratio at the 97.5% level. It is important to keep in mind that a relatively weaker performance of the ULUA measure discussed below may stem, at least, partially from the data quality problems.

Explanatory variables include, in addition to the asset encumbrance measures, CAMEL and control variables. We use the following CAMEL variables:

- The Tier 1 capital ratio, which represents the ratio of high-quality capital (shareholders' capital, reserves and other perpetual capital resources such as subordinated debt), divided by risk-weighted assets (RWA).

- The ratio of unreserved impaired loans to equity, which is another indicator of the quality of the loan portfolio but expressed relative to common equity. It is also known as the "capital impairment ratio".

- The return on assets ratio (ROA), which is an indicator of the return on a firm's investments and is calculated by dividing the bank's net income over its total assets.

- The net loans to deposits and short-term funding ratio, which is a measure of structural liquidity. A lower value of the ratio means the bank relies to a greater extent on more stable deposit funding, as opposed to wholesale funding, to finance its loan book.

- The liquid assets to total assets ratio, which measures the amount of liquid assets that the bank holds and that could be converted into cash to withstand a liquidity stress event.

In our robustness exercise we extend this set of CAMEL variables to include other characteristics of bank operations as in Chiaramonte and Casu (2013), in particular, bank's leverage ratio, the ratio of loan-loss reserve to gross loans, which measures the quality of the loan portfolio by indicating the proportion of reserves for losses relative to the banks' loan portfolio, and the return on equity ratio (ROE). Due to potential multicollinearity issues, we treat as baseline the set of CAMEL variables listed above rather than the extended one. As in the case of missing matching liabilities, we impute the few missing CAMEL variable from the median values of the corresponding variables of banks belonging to similar size group and business type.

Control variables include bank size (measured by the natural logarithm of total assets) and central bank exposure to total liabilities. We include dummy variables to differentiate the business model of the institution using three categories: "Commercial banks and Bank holding companies (BHC)", "cooperative and savings banks" and "other banks". We also include dummy variables indicating banks incorporated in Eurozone and banks from the GIIPS countries. Furthermore, we include a dummy variable to identify which banks are investment grade. We use implied ratings in order to avoid compromising the sample size, in a similar fashion to CDS spreads. Implied ratings are provided by Fitch Solutions and derived from proprietary fundamental data. These provide a forward-looking assessment of the stand-alone financial strength of a bank and are categorized according to a 10-point rating scale from A to F where A denotes the maximum creditworthiness, with four interim scores (A/B, B/C, C/D and D/E).

Our final data sample includes institutions with total assets above €1bn for which CDS spreads, asset encumbrance, CAMEL and control variables are available, resulting in 534 banks from 21 countries.

Table 1 presents the summary statistics of the variables of study. The mean values of AE, AE^+ and ULUA are 12.8%, 13.2% and 0.92 respectively.[8] Note that there is a wide disparity across banks in our sample. AE and AE^+ present standard deviations of 9.1% and 9.3% respectively, while the coefficient of variation of ULUA is significantly lower. One should also mention that the AE and AE^+ measures are highly correlated (coefficient of correlation 0.98),

[8]These average encumbrance measures are somewhat lower than the ones estimated by EBA. This is likely to be driven by the fact that EBA collects information mostly from larger banks. See also the comments to Table 2.

while ULUA is correlated only moderetly with the other encumbrance measures (0.49 and 0.47 with AE and AE^+ correspondingly).

[Table 1]

Table 2 shows the mean levels of the asset encumbrance ratios across rating categories. If anything, banks within the most extreme categories, A/B and E/F, present the lowest mean AE and AE^+ ratios of all categories. For ULUA, the pattern of means conditional on credit rating is even less obvious.

[Table 2]

As shown in the same table, mean encumbrance levels tend to increase with bank size, measured in terms of total assets, across all ratios. This can be related to the fact that securitisation — an important source of encumbrance — involves substantial costs, mostly of a fixed nature, which could be particularly important to issue for smaller banks (Adrian and Shin (2010), Panetta and Pozzolo (2010), Carbó-Valverde, Marques-Ibanez, and Rodríguez-Fernández (2012)). Table 2 also reports the mean ratio levels by type of institution. We distinguish between "commercial banks and bank holding companies (BHC)", "cooperative banks", "savings banks" and "other banks", including mortgage banks and pure investment banks. Savings banks tend to have lower levels for both $AE(^+)$ and ULUA.

Summary statistics of variables used in the baseline cross-sectional estimation is presented in Table 3. In our regression analysis, we use log transformations of encumbrance ratios as it seems reasonable to assume that the effect of encumbrance is not linear. We also report the summary statistics of off- and on-balance sheet ratios, in particular, (log of) encumbered assets on- and off- balance sheet to on-balance encumbrance ($ln\ AE^{On+Off}$ / AE^{On}), as well as the log ratio of on-balance assets to total — on- and off-balance — assets ($ln\ TA^{On}$ / TA^{On+Off}). We do this to compare the statistical relationship between AE, AE^+ and CDS: as AE^+ can be related to AE via simple adjustments through on- and off-balance encumbrance and total assets, one can analyze the exact source of statistical association between AE^+ and bank credit risk. Similarly, for low levels of AE, log of ULUA can be approximated as on-balance sheet encumbrance adjusted for the log of the share of total assets financed with unsecured liabilities (*ln* UL / TA). We report the latter as well to support further discussion of the relevance of different metrics of encumbrance.

[Table 3]

5.2 Regression analysis

Table 4 reports the results of the baseline regressions. To account for the potential correlation of the errors among the banks belonging to the same business category in a given country, we apply country-business model clustering in all our regression models. The latter restricts the inference to rather conservative conclusions in which, for example, German saving banks are effectively treated as one observation when assessing the statistical importance of the effects. Column 1 reports the association of encumbrance and CDS premiums without conditioning on bank or country characteristics. Column 2 adds observables; column three eliminates between-country variation and conditions on bank business model.

[Table 4]

A negative and significant association between banks' implied CDS spreads and asset encumbrance emerges across all models. That is, higher levels of on-balance sheet encumbrance are associated with *lower* levels of credit risk premiums, although, quantitatively the relationship is rather moderate. This result is robust to conditioning on observable characteristics, as well as to accounting for unobservable determinants of CDS and asset encumbrance at the levels of country and business model. Thus, our initial evidence suggests a net positive perception of creditors towards asset encumbrance. As suggested in the theoretical discussion, higher collateralisation could lead to a lower probability of default due to diminished liquidity risks and, hence, reduce credit risk premiums.

Table 5 reports similar results with AE^{+} as the explanatory variable.[9] Given high correlation of the simple on-balance sheet encumbrance AE and its off-balance sheet augmented version AE^{+}, the robustness of our previous conclusions is not surprising. What is more interesting is the separate role of off-balance sheet encumbrance in this relationship. Intuitively, the difference between AE and its augmented version AE^{+} is driven by the total-to-on-balance encumbrance ratio AE^{On+Off} / AE^{On}, and the share of on-balance activities in the total balance sheet of a bank TA^{On} / TA^{On+Off}. Hence, lower panel of Table 5 reports the estimates where *ln* AE^{+} is replaced with a linear combination of the above three components. It shows that much of the relationship between AE^{+} and CDS can be attributed to the co-movement of on-balance encumbrance AE with bank credit risk while the other two components play a smaller role. Thus, the ratio of total encumbrance to on-balance sheet collateral appears to be positively

[9] We do not report coefficients on the control variables to preserve space — full outputs can be obtained from authors on request.

related to CDS, however, this result is robust only when conditioning on other observable characteristics. Given that 81% of banks in our sample do not have off-balance encumbrance, this result should be taken with caution. The general off-balance sheet activities, in their turn, do not exhibit any statistical association with the levels of bank credit risk.

[Table 5]

Table 6 presents the results of a similar exercise with ULUA. In general when measured as the ratio of unsecured liabilities to unencumbered assets, the negative relationship between encumbrance and bank credit risk is somewhat weaker statistically. This could be related to the problems of reporting of matching liabilities discussed above, or to the fact that ULUA captures both the encumbrance composition of the asset side of banks' balance sheets as well as their shares of unsecured funding. When these two factors are included in the regression separately (lower panel of Table 6), only the asset side encumbrance ratio AE remains statistically relevant.

[Table 6]

We next perform a series of robustness checks of the above-mentioned results. First, following Chiaramonte and Casu (2013) we include other CAMEL variables to account for other factors that may drive encumbrance and CDS premiums. The results are reported in Table 7. On-balance encumbrance ratio AE remains negatively associated with bank credit risk at conventional levels of statistical significance.

[Table 7]

Next, we include past levels of credit risk (average of daily *ln* CDS in 2014) as an additional control (Table 8, upper panel). All the specifications — including the ones with ULUA — demonstrate the established negative relationship between encumbrance ratios and credit risk levels in 2015. We further rerun our baseline specifications using weighted estimators where weight of each observation is proportional to bank total assets. By doing this we aim to test the sensitivity of our conclusions to imposing lower weights of observations corresponding to smaller banks — especially saving and cooperative banks in Germany and Italy — that dominate our sample. The lower panel of Table 8 demonstrates that, if anything, the estimated relationship becomes more sizable economically.

[Table 8]

In our next round of robustness checks we extend the sample in time and include encumbrance data from the years 2016 and 2017. This, however, drastically affects the sample size. First, the implied CDS spreads are no longer provided by Fitch Solutions for the later years of the sample. Hence, we opt for implied CDS provided by Bloomberg, and the latter has a lower coverage. Secondly, many banks do not keep the older reports on their web sites and disclose only current financial data which makes it difficult to obtain encumbrance ratios for the interim period. The rest of the variables are obtained and constructed in the way similar to the cross-sectional data set. The matched sample of extended encumbrance measures and implied CDS contains 99 banks.[10] The summary statistics of variables used in panel estimation is reported in Table 9.

[Table 9]

Table 10 presents the panel estimates. We run regression specifications both in levels and in differences to verify the stability of the baseline result. Column 1 and 2 report specifications in levels with the latter presenting the estimates of the relationship between asset encumbrance and bank risk using only within bank variation. Columns 3 and 4 instead present estimates obtained in first differences — without and with control variables, correspondingly. In addition to the standard controls, in each regression we condition on the year indicators. The results confirm our baseline conclusion that higher on-balance encumbrance ratio is associated with lower credit risk. Given that between-bank variation is the predominant source of variation of encumbrance ratios, we find these results particularly important.

[Table 10]

5.3 Heterogeneity of the relationship between asset encumbrance and bank credit risk

While the results of the previous section conform well with the predictions of the theoretical model in part of average co-relation of encumbrance levels and bank credit risk, its conclusions are silent about the heterogeneity of this relationship and its sources. In this section, we fill in this gap.

We perform the analysis of effect heterogeneity with the baseline cross-sectional data of encumbrance ratios in 2015. Furthermore, rather than following the traditional approach of interacting encumbrance ratios with all potential bank characteristics to study the dimensions of

[10]Matching encumbrance with market CDS would result in a sample that is more than three times smaller.

heterogeneity, we opt for grouping CAMEL variables into a smaller number of factors that underlie bank financial ratios. This allows for a clearer separation of the forces that drive encumbrance-risk heterogeneity, and at the same time minimizes the issues of multicollinearity that could arise when several interaction variables have strong common components.

In particular, we perform a simple Principal Component Analysis of the correlation matrix of bank CAMEL variables included as control variables in the previous section, i.e. The Tier 1 capital ratio, The ratio of unreserved impaired loans to equity, The return on assets ratio, The net loans to deposits and short-term funding ratio, and The liquid assets to total assets ratio.[11] We choose two principal components that explain approximately 60% of total variance. The resulting factor loadings are reported in Table 11.

[Table 11]

The table indicates that the first factor loads positively on bank capital and profitability and negatively on low quality of loans as measured by the ratio of unreserved impaired loans to equity. At the same time, it has close to zero relevance to liquidity variables. Hence, we call the first component "Capital": it reflects profitability of the assets as well as risks associated with their quality and leverage structure. Higher Capital scores are assigned to well capitalized banks with profitable assets and high quality of credit portfolios. The second component, on the contrary, loads positively on loans to deposits ratio and negatively on the share of liquid assets in total assets of a bank. Since in the case of the second component the loadings on capital-related ratios are substantially smaller in magnitude, we call it "Illiquidity" factor. Hence, higher values of the predicted scores for the Illiquidity factor indicate *lower* liquidity of bank's balance sheet or more fragile funding structure.

We next proceed by running baseline regressions similar to the ones of Table 4 but with AE ratio interacted with the Capital and Illiquidity scores of each bank obtained from PCA. The results are presented in Table 12, where both scores are demeaned and standardized to have unit standard deviation. Columns 1 and 2 introduce interaction of AE with the Capital score, unconditionally as well as with the full set of controls and country fixed effects estimator. The capital score is negatively associated with the credit risk. Also, similarly to the results of the previous section, a bank with an average capital score demonstrates negative relationship between encumbrance and credit risk. However, the association of encumbrance and CDS premium does not seem to depend much on the capital score of the bank: the estimated coefficients on the interaction of AE and capital score are close to zero and very imprecise.

[11] We also performed factor analysis of the correlation matrix of these variables and obtained conceptually very similar results.

[Table 12]

Bank's liquidity, on the contrary, seems to be more relevant for the relationship between its encumbrance and credit risk. Thus, the coefficient on double interaction of AE and Illiquidity score is positive and statistically significant at conventional levels. Moreover, liquidity seems to have a strong economic significance for the estimated relationship between encumbrance and credit risk: the interaction coefficient is of the same magnitude as the non-interacted AE. Thus, an increase of one standard deviation in Illiquidity score can offset the negative relationship between encumbrance and credit risk. Put differently, for banks with sufficiently illiquid balance sheets, higher encumbrance ratio correlates positively with CDS premiums — contrary to the conclusions of the previous section. At the same time, the negative relationship between AE and credit risk that was established earlier characterizes banks with the average liquidity scores. The negative relationship is quantitatively more pronounced for banks with abnormally high liquidity in their balance sheets. To the extent the balance sheet liquidity proxies well the degree of fire-sale discounts, the results in Section 5 provide a further theoretical basis for the above-mentioned heterogeneity.

6 Conclusion

Asset encumbrance has been a much-discussed subject in recent literature and policymakers have been actively addressing what some regulators consider to be excessive levels of asset encumbrance. In this paper, we provide a theoretical model that captures the relationship between asset encumbrance and bank liquidity risk. According to this model, secured funding serves as a mechanism that change bank's exposure to liquidity risks. When unencumbering bank's assets is not costly, a bank can fully exploit the stability of secured financing and reduce its liquidity risks associated with the unsecured debt holders. Hence, asset encumbrance and risk premiums would have a negative relationship.

In an alternative situation when a bank faces high costs of unencumbering its assets, secured funding can have an opposite effect on bank's liquidity risk. In this case, the negative structural subordination effect dominates the positive impact of asset encumbrance. Hence, the relationship between encumbrance and bank risk premiums can be positive when a bank faces adverse conditions of transferring its collateral.

We next provide empirical analysis that supports the theoretical predictions. We show that asset encumbrance is, on average, negatively associated with bank risk across different asset encumbrance measures. We also show that liquidity of bank plays a mediating role in the relationship between asset encumbrance and bank risk. Thus, for banks with less liquid balance sheets, higher encumbrance ratios are likely to signal higher credit risks. On the contrary, banks with more liquid assets or more stable funding exhibit stronger negative relationship between asset encumbrance and CDS premiums. These results suggest that regulators need to be cautious before leaping to all-encompassing conclusions when assessing the effects of asset encumbrance levels.

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A Appendix: Proofs

Proof of Proposition 1. Combine the definition of $\underline{\theta}$ (2) with the break-even condition (3):

$$\begin{aligned}(1-s)(1+\gamma) &= \int_0^{\underline{\theta}} (\theta + k\phi - s(1+c))\,\mathrm{d}F + \int_{\underline{\theta}}^{\bar{\theta}} (1-s)D\,\mathrm{d}F \\ &= k\phi - s(1+c) + \underline{\theta}(1-F(\underline{\theta})) + \int_0^{\underline{\theta}} \theta\,\mathrm{d}F,\end{aligned}$$

which implicitly defines $\underline{\theta}(s)$. Apply implicit function theorem to get

$$\frac{\partial \underline{\theta}}{\partial s} = \frac{c-\gamma}{1-F(\underline{\theta})}.$$

Obviously,

$$\frac{\partial \underline{\theta}}{\partial s} \lesseqgtr 0 \quad \Leftrightarrow \quad c \lesseqgtr \gamma.$$

Q.E.D.

Proof of Proposition 2. Use (2) to express bank profit Π (4) as

$$\begin{aligned}\Pi &= \int_{\underline{\theta}}^{\bar{\theta}} (\theta + k - s - (1-s)D)\,\mathrm{d}F \\ &= \int_{\underline{\theta}}^{\bar{\theta}} (\theta + k - s - [\underline{\theta} + k\phi - s(1+c)])\,\mathrm{d}F \\ &= \int_{\underline{\theta}}^{\bar{\theta}} \theta\,\mathrm{d}F + [k(1-\phi) + sc - \underline{\theta}](1-F(\underline{\theta})),\end{aligned}$$

and differentiate it with respect to s:

$$\begin{aligned}\frac{\mathrm{d}\Pi}{\mathrm{d}s} &= \left(c - \frac{\partial \underline{\theta}}{\partial s}\right)(1-F(\underline{\theta})) - [k(1-\phi)+sc]f(\underline{\theta})\frac{\partial \underline{\theta}}{\partial s} \\ &= \gamma - cF(\underline{\theta}) - [k(1-\phi)+sc](c-\gamma)H(\underline{\theta}),\end{aligned}$$

where $H(.)$ is the hazard function of θ. Next, $c < \gamma$ implies $cF(\underline{\theta}) < \gamma$. Then, $\frac{\mathrm{d}\Pi}{\mathrm{d}s} > 0$ for all $s \in [0, k\phi]$ so that at the optimum $s^* = k\phi$.
Q.E.D.

Proof of Proposition 1. Since $s^* = k\phi$,

$$\frac{\mathrm{d}s^*}{\mathrm{d}k} = \phi > 0.$$

Next, from the definition of $\underline{\theta}$ (2) we get

$$D = \frac{\underline{\theta} + k\phi - s(1+c)}{1-s}. \tag{6}$$

We have $D = D(s, \underline{\theta}(s))$, so that

$$\begin{aligned}
\frac{\mathrm{d}D}{\mathrm{d}s} &= \frac{\partial D}{\partial s} + \frac{\partial D}{\partial \underline{\theta}} \frac{\partial \underline{\theta}}{\partial s} \\
&= \frac{-(1-s)(1+c) + \underline{\theta} + k\phi - s(1+c)}{(1-s)^2} + \frac{1}{1-s} \frac{c-\gamma}{1-F(\underline{\theta})} \\
&= \frac{1}{1-s}\left[\frac{\underline{\theta} + k\phi - (1+c)}{1-s} + \frac{c-\gamma}{1-F(\underline{\theta})}\right].
\end{aligned}$$

To do comparative statics with respect to k, define explicitly $s = s(k)$ and $\underline{\theta} = \underline{\theta}(s(k), k)$. Then from (6), $D = D(s(k), \underline{\theta}(s(k), k), k)$, and

$$\begin{aligned}
\frac{\mathrm{d}D}{\mathrm{d}k} &= \frac{\partial D}{\partial s} \frac{\mathrm{d}s}{\mathrm{d}k} + \frac{\partial D}{\partial \underline{\theta}} \frac{\mathrm{d}\underline{\theta}}{\mathrm{d}k} + \frac{\partial D}{\partial k} \\
&= \left[\frac{\mathrm{d}D}{\mathrm{d}s} - \frac{\partial D}{\partial \underline{\theta}} \frac{\partial \underline{\theta}}{\partial s}\right] \frac{\mathrm{d}s}{\mathrm{d}k} + \frac{\partial D}{\partial \underline{\theta}} \left[\frac{\partial \underline{\theta}}{\partial k} + \frac{\partial \underline{\theta}}{\partial s} \frac{\mathrm{d}s}{\mathrm{d}k}\right] + \frac{\partial D}{\partial k} \\
&= \frac{\mathrm{d}D}{\mathrm{d}s} \frac{\mathrm{d}s}{\mathrm{d}k} + \frac{\partial D}{\partial \underline{\theta}} \frac{\partial \underline{\theta}}{\partial k} + \frac{\partial D}{\partial k}.
\end{aligned}$$

From (6) and from (3):

$$\frac{\partial D}{\partial \underline{\theta}} = \frac{1}{1-s}, \quad \frac{\partial \underline{\theta}}{\partial k} = -\frac{\phi}{1-F(\underline{\theta})}, \quad \frac{\partial D}{\partial k} = \frac{\phi}{1-s}.$$

so that

$$\frac{\mathrm{d}D}{\mathrm{d}k} = \frac{1}{1-s}\left[\frac{\underline{\theta} + k\phi - (1+c)}{1-s} + \frac{c-\gamma}{1-F(\underline{\theta})}\right] \frac{\mathrm{d}s}{\mathrm{d}k} - \frac{F(\underline{\theta})}{1-F(\underline{\theta})} \frac{\phi}{1-s}. \tag{7}$$

At the optimum $s^* = k\phi$, hence:

$$\frac{\mathrm{d}D^*}{\mathrm{d}k} = \frac{\phi}{1-k\phi}\left[\frac{\underline{\theta} + k\phi - (1+c)}{1-k\phi} + \frac{c-\gamma-F(\underline{\theta})}{1-F(\underline{\theta})}\right].$$

It follows that $\frac{\mathrm{d}D^*}{\mathrm{d}k}$ is negative as long as the expression in the square brackets is negative, or, equivalently,

$$\frac{\mathrm{d}D^*}{\mathrm{d}k} < 0 \quad \Leftrightarrow \quad \underline{\theta}(1-F(\underline{\theta})) < (1+\gamma)(1-k\phi) + (k\phi - F(\underline{\theta}))c.$$

From the break-even condition (3),

$$\underline{\theta}(1-F(\underline{\theta})) = (1+\gamma)(1-k\phi)+k\phi c-\int_0^{\underline{\theta}} \theta \, \mathrm{d}F,$$

hence, the above condition can be rewritten as

$$\frac{\mathrm{d}D^*}{\mathrm{d}k} < 0 \quad \Leftrightarrow \quad c < E[\theta|\theta < \underline{\theta}(c)].$$

In particular,

$$c = 0 \quad \Rightarrow \quad \frac{\mathrm{d}D^*}{\mathrm{d}k} < 0.$$

Finally, since $E[\theta|\theta < \underline{\theta}(c)]$ is an increasing continuous function of c and $E[\theta|\theta < \underline{\theta}(0)] > 0$, $\frac{\mathrm{d}D^*}{\mathrm{d}k} < 0$ for c sufficiently close to 0.
Q.E.D.

Proof of Proposition 3. We are in the case when $c > \gamma$ and, hence, $\frac{\partial \underline{\theta}}{\partial s} > 0$.

The FOC is:

$$\frac{\mathrm{d}\Pi}{\mathrm{d}s} = \gamma - cF(\underline{\theta}(s)) - [k(1-\phi)+sc](c-\gamma)H(\underline{\theta}),$$

where optimal s is in $[0, k\phi]$. Note that the SOC is:

$$\frac{\mathrm{d}^2\Pi}{\mathrm{d}s^2} = -cf(\underline{\theta})\frac{\partial \underline{\theta}}{\partial s} - c(c-\gamma)H(\underline{\theta}) - (k(1-\phi)+sc)(c-\gamma)\frac{\partial H}{\partial \underline{\theta}}\frac{\partial \underline{\theta}}{\partial s}$$

which is negative for any optimal (corner or interior) s.

We have three sub-cases:

(i) corner solution with $s^* = 0$,

(ii) positive interior solution $s^* \in (0, k\phi)$,

(iii) corner solution with $s^* = k\phi$.

Consider the corner solutions first.

The sub-case (i) happens when

$$\left.\frac{\mathrm{d}\Pi}{\mathrm{d}s}\right|_{s=0} = \gamma - cF(\underline{\theta}(0)) - k(1-\phi)(c-\gamma)H(\underline{\theta}(0)) \le 0,$$

and in this case, in equilibrium $s^* = 0$. The above condition can be rewritten as

$$c \geq \bar{c} \quad \text{where} \quad \bar{c} \equiv \gamma \frac{1 + k(1-\phi)H(\underline{\theta}(0))}{F(\underline{\theta}(0)) + k(1-\phi)H(\underline{\theta}(0))}.$$

Note that at $s = 0$, $\underline{\theta}$ does not depend on c, so that the RHS of the above definition is independent of c.

The sub-case (iii) happens when

$$\left.\frac{\mathrm{d}\Pi}{\mathrm{d}s}\right|_{s=k\phi} = \gamma - cF(\underline{\theta}(k\phi)) - k(1-\phi(1-c))(c-\gamma)H(\underline{\theta}(k\phi)) \geq 0,$$

and in this case, in equilibrium, $s^* = k\phi$.

The above condition can be rewritten as $c \leq J(c)$, where $J(c)$ is defined as

$$J(c) \equiv \gamma \frac{1 + k[1-\phi(1-c)]H(\underline{\theta}(k\phi))}{F(\underline{\theta}(k\phi)) + k(1-\phi(1-c))H(\underline{\theta}(k\phi))}.$$

The sign of $\frac{\mathrm{d}J}{\mathrm{d}c}$ is determined by

$$\begin{aligned}
&\left[k[1-\phi(1-c)]\frac{\partial H}{\partial \underline{\theta}}\frac{\partial \underline{\theta}}{\partial c} + k\phi H(\underline{\theta})\right]\left[F(\underline{\theta}) + k(1-\phi(1-c))H(\underline{\theta})\right] \\
&- \left[k[1-\phi(1-c)]\frac{\partial H}{\partial \underline{\theta}}\frac{\partial \underline{\theta}}{\partial c} + k\phi H(\underline{\theta}) + f(\underline{\theta})\frac{\partial \underline{\theta}}{\partial c}\right]\left[1 + k[1-\phi(1-c)]H(\underline{\theta})\right] \\
&= -\left[k[1-\phi(1-c)]\frac{\partial H}{\partial \underline{\theta}}\frac{\partial \underline{\theta}}{\partial c} + k\phi H(\underline{\theta})\right](1-F(\underline{\theta})) - f(\underline{\theta})\frac{\partial \underline{\theta}}{\partial c}.
\end{aligned}$$

Furthermore, since $\underline{\theta}$ is implicitly defined as a function of c by the break-even condition (3), one gets

$$\frac{\partial \underline{\theta}}{\partial c} = \frac{s}{1-F(\underline{\theta})},$$

which is positive at $s = k\phi$. Hence, $\frac{\mathrm{d}J}{\mathrm{d}c} < 0$ for all c (as long as $\frac{\partial H}{\partial \underline{\theta}} \geq 0$ as we have assumed), and the necessary condition for the sub-case (iii) can be rewritten as

$$c \leq \underline{c}, \quad \text{where } \underline{c} \text{ is defined by } \underline{c} = J(\underline{c}).$$

Finally, we show that $J(c) < \bar{c}$ for all c. To see this, note that since $\frac{\partial J}{\partial c} < 0$, it suffices to show that $J(0) < \bar{c}$. At $c = 0$, the sign of $J(0) - \bar{c}$ is determined by

$$
\begin{aligned}
&\Big[1 + k(1-\phi)H(\underline{\theta}(k\phi))\Big]\Big[F(\underline{\theta}(0)) + k(1-\phi)H(\underline{\theta}(0))\Big] \\
&- \Big[F(\underline{\theta}(k\phi)) + k(1-\phi)H(\underline{\theta}(k\phi))\Big]\Big[1 + k(1-\phi)H(\underline{\theta}(0))\Big] \\
&= F(\underline{\theta}(0)) - F(\underline{\theta}(k\phi)) + k(1-\phi)H(\underline{\theta}(0))(1 - F(\underline{\theta}(k\phi))) - k(1-\phi)H(\underline{\theta}(k\phi))(1 - F(\underline{\theta}(0))) \\
&< F(\underline{\theta}(0)) - F(\underline{\theta}(k\phi)) < 0,
\end{aligned}
$$

where the second to last inequality follows from the observation that $\frac{\partial \underline{\theta}}{\partial s} > 0$ and, as a consequence, $F(\underline{\theta}(k\phi)) > F(\underline{\theta}(0))$ and $H(\underline{\theta}(k\phi)) > H(\underline{\theta}(0))$. Hence, $J(c) < \bar{c}$ which implies $\underline{c} < \bar{c}$. Note also, that $\underline{c} > \gamma$ which is consistent with the original assumption $c > \gamma$.

Consider the intermediate case (ii) with $\frac{\mathrm{d}\Pi}{\mathrm{d}s}\big|_{s=k\phi} < 0$ and $\frac{\mathrm{d}\Pi}{\mathrm{d}s}\big|_{s=0} > 0$ which happens whenever $\underline{c} < c < \bar{c}$ or, equivalently, when

$$
k(1-\phi) < \frac{\gamma - cF(\underline{\theta}(s))}{c-\gamma}\frac{1}{H(\underline{\theta}(s))} < k(1 - \phi(1-c)). \tag{8}
$$

By intermediate value theorem, there must exist at least one $s^* \in (0, k\phi)$ such that $\frac{\mathrm{d}\Pi}{\mathrm{d}s} = 0$.

The FOC determining s^* can be expressed as

$$
\begin{aligned}
s^* &= G(s^*) \\
G(s) &= \frac{1}{c}\left[\frac{\gamma - cF(\underline{\theta}(s))}{c-\gamma}\frac{1}{H(\underline{\theta}(s))} - k(1-\phi)\right].
\end{aligned}
$$

By (8), $0 < G(s) < k\phi$. Furthermore, because θ has non-decreasing hazard function, $\frac{\mathrm{d}G}{\mathrm{d}s} < 0$. To see this, note that

$$
\frac{\mathrm{d}G}{\mathrm{d}s} = \frac{\partial G}{\partial \underline{\theta}}\frac{\partial \underline{\theta}}{\partial s}, \quad \frac{\partial G}{\partial \underline{\theta}} = -\frac{1}{cH(\underline{\theta})}\left[\frac{\gamma - cF(\underline{\theta})}{c-\gamma}\frac{1}{H(\underline{\theta})}\frac{\partial H}{\partial \underline{\theta}}(\underline{\theta}) + \frac{cf(\underline{\theta})}{c-\gamma}\right].
$$

By (8), $cF(\underline{\theta}) < \gamma$. Then, a sufficient condition for $\frac{\partial G}{\partial \underline{\theta}} < 0$ is $\frac{\partial H}{\partial \theta} \geq 0$. Hence, we have $\frac{\partial G}{\partial \underline{\theta}} < 0$ and $\frac{\mathrm{d}G}{\mathrm{d}s} < 0$, which together with the condition $0 < G(s) < k\phi$ imply that there is unique $s^* \in (0, k\phi)$ such that $s^* = G(s^*)$.

Q.E.D.

B Appendix: Definitions and Sources of Asset Encumbrance

In this section we review the definitions of asset encumbrance and describe how assets become encumbered. We also review the most common sources of asset encumbrance (i.e. the liabilities or obligations that give rise to encumbered assets).

B.1 Defining asset encumbrance

European regulations define encumbered assets as "*assets pledged or subject to any form of arrangement to secure, collateralize or credit enhance any transaction from which it cannot be freely withdrawn*".[12] The Basel Committee on Banking Supervision (BCBS) defines unencumbered assets as those assets which are "*free of legal, regulatory, contractual or other restrictions on the ability of the bank to liquidate, sell, transfer, or assign the asset*".[13]

To clarify the definition of encumbrance, let us consider a bank (Bank A) whose assets include loans and a portfolio of securities (government or corporate bonds, equities, etc.), financed via equity capital, retail deposits and unsecured wholesale funding, as shown in the left hand side of figure 5. Bank A could obtain additional funding from a counterparty, let us say Bank B, by entering into a secured financing transaction, as shown in the right hand side of figure 5. Under such arrangement Bank A provides collateral to Bank B in order to mitigate the risk of failing to keep interest repayments or repaying the borrowings. In exchange, Bank A benefits from cheaper funding when compared to an equivalent unsecured transaction.[14] The arrangement imposes restrictions to Bank A on its ability to sell, transfer or dispose of the collateral provided during the term of the transaction. Bank A would consider such assets encumbered.

[Figure 5]

Figure 5 represents the securities provided as collateral as recorded or recognised in Bank A's balance sheet rather than being transferred to Bank B's balance sheet. Collateral obtained by Bank B is therefore represented in an off-balance sheet (OBS) rather than an on-balance sheet, and is known as "OBS collateral" or simply "collateral received". The assumption that the collateral remains recognised from Bank A's balance sheet is a necessary condition for being considered an encumbered asset of Bank A. If the assets used as collateral were derecognised

[12] See European Commission (2015).

[13] See BCBS (2013)

[14] In addition, the arrangement may provide for savings in regulatory capital requirements to Bank B as well as lower regulatory liquidity requirements to Bank A and Bank B.

by Bank A then they would be recognised by Bank B and they would not be encumbered for Bank A.

In practice, the recognition or derecognition of collateral provided depends on the contractual terms of the transaction as well as its accounting treatment. Derecognition cannot occur unless the securities are transferred to the counterparty. This can be achieved by using "title transfer" arrangements, whereby full ownership of the collateral is passed on to the counterparty during the term of the transaction.[15] Collateral can also be provided under "security interest" arrangements, which do not transfer ownership but concede rights to the counterparty to obtain full ownership of the collateral under some pre-determined event, such as failure to repay.[16] The use of one technique over the other depends on market practice. Collateral provided in secured financing transactions such as repurchase agreements (i.e. repo) is typically provided by way of title transfer whereas collateral used as a margin for OTC derivatives can be provided using both methods.[17]

The transfer of title over collateral, however, is not a sufficient condition for derecognition to occur, with the actual outcome depending on the applicable accounting treatment. Under International Financial Reporting Standards (IFRS), IAS 39 applies a set of tests to assess whether (i) the risks and rewards and (ii) control over the asset have been transferred.[18] If the risks and rewards have not been transferred, or in other words, if the collateral provider continues to be exposed to the risks of ownership of the assets such as loss in market value and/or the benefits that they generate such as dividends, then the collateral would remain recognised on its balance even if a transfer of assets has occurred. But even if the risks and rewards had been transferred, further control tests are undertaken to understand which entity controls the asset. If the collateral provider could direct how the benefits of that asset are realised, then the collateral would not be derecognised either.

As illustrated in figure 5, the value of securities that Bank A posted as collateral is higher than the value of the borrowings. This practice is known as overcollateralisation and is intended to mitigate the risk of the collateral falling in value during the term of the transaction. It is usually undertaken by means of a "haircut" or "margin ratio".[19] Collateral agreements often

[15] Under title transfer, Bank B would have to return the collateral (or equivalent securities) to Bank A when the original transaction matures.

[16] Security interest arrangements are also known as collateral pledges.

[17] Under English Law the collateral for OTC derivatives is typically provided by way of title transfer, whereas under New York Law collateral is typically provided under security interest.

[18] The treatment under US GAAP (ASC 860) differs from IFRS since the focus is on whether the transferor has surrendered control over a financial asset.

[19] The agreed haircut or margin ratio determines the percentage by which the market value of a security is reduced for the purpose of calculating the amount of collateral being provided.

require a frequent (sometimes daily) marked-to-market valuation of the collateral and requests to top up the value of collateral, known as collateral calls, may be triggered if its market value falls below certain pre-determined threshold amounts.

Even in the case in which the collateral received is not reflected in its balance sheet, Bank B could reuse some or all of the collateral received from Bank A to obtain financing from a third party (let us say, Bank C). As illustrated in figure 6, this re-use of collateral by Bank B would result in the encumbrance of OBS collateral. As such, encumbrance can affect both on-balance sheet assets as well as OBS collateral. The practice of providing collateral that has been previously received is known as collateral re-use or re-hypothecation. It is common practice and may result in long "collateral chains".[20].

[Figure 6]

B.2 Sources of asset encumbrance

The liabilities or obligations that give rise to encumbered assets are known as "sources of asset encumbrance" or "matching liabilities". The typical bank will have encumbered assets from several sources but the simplest institutions may rely only on a single source or may present no encumbered assets at all. We now discuss some of the most common sources of asset encumbrance.[21]

B.2.1 Secured financing transactions

Secured financing transactions encompass myriad transactions involving the temporary provision of securities to borrow cash or other securities. Common types include repurchase agreements (repos), buy/sell backs or securities borrowing and lending. Collateral in repo is provided under a title transfer but it remains recognised in the balance sheet of the collateral provider's

[20]The terms re-hypothecation and re-use are often used interchangeably and we will do so here. In practice there are legal distinctions between them that may be relevant in a different context. Recent studies have analysed the concept of re-hypothecation and "collateral velocity". Analytical work includes Adrian and Shin (2010) and Singh (2010) More recent work has focussed on liquidity mismatches and the role of collateral in intermediation chains. Brunnermeier and Krishnamurthy (2014) introduced the Liquidity Mismatch Index (LMI) which compares the market liquidity of assets and the funding liquidity of liabilities, thus capturing the length of collateral intermediation chains.

[21]In addition to the sources covered in this section, transactions that may result in encumbered assets include collateral swaps, also known as collateral upgrade transactions, where collateral of a different quality is exchanged. Collateralised guarantees rely on securities to secure an existing or future liability. Other arrangements, such as factoring which include the transfer of trade receivables to an institution may result in similar encumbrance to securitisations.

(i.e. the repo seller) since the risks and rewards of the collateral are retained.[22] Thus, repo collateral is encumbered for the collateral provider. Encumbered assets in repo are predominantly government bonds, followed by corporate bonds and covered bonds. Asset-backed securities and equities are also used as collateral. Most of the funding provided by central banks is transacted through repo. Like Dexia, many European banks were, and some still are, heavily reliant on repo financing from the ECB.

B.2.2 Asset-backed securities (ABS) and mortgage-backed securities (MBS)

Another potential source of asset encumbrance is securitisations. These entail ABS and MBS bonds or notes being issued and receivables, which may include retail or commercial mortgages in MBS, or credit card debt or other loans in ABS, being used as collateral.

A traditional two-step securitisation involves the initial transfer of the receivables of the originating bank to a Special Purpose Vehicle (SPV) and the sale of the ABS or MBS to investors. The overall securitisation structure is intended to make sure that there is a true sale of receivables to the SPV and that the SPS is "bankruptcy remote". Accounting standards however, may require that the SPV is consolidated into the "sponsoring" bank balance sheet, including all of its assets and liabilities, even the receivables.[23] If the underlying receivables were consolidated, this would result in the recognition of such receivables on the sponsor's balance sheet. However, tests to assess whether the assets meet the criteria for accounting derecognition, as discussed earlier, shall still be undertaken. If derecognition criteria are not met the receivables would be encumbered. This is often the case since it is common for the sponsoring bank to keep an active role in the securitisation, for example, by servicing the assets or providing support by retaining certain tranches to absorb first losses and potential risks in relation to timings in the collection of the receivables.

ABS or MBS can be used as collateral to raise funding with counterparties and central banks. Thus, a common practice across some banks, especially during the Eurozone crisis, is the retention of their self-issued ABS or MBS rather than its sale to investors.[24] If notes are retained, they would not be encumbered. But if the notes are used to raise fresh funding, for

[22]If this was not the case, banks could artificially reduce its overall leverage by derecognising collateral in repurchase agreements. This treatment was exploited by Lehman Brothers under the well-known "Repo 105" scheme, characterised by the New York Attorney General Andrew Cuomo as a "massive accounting fraud" and leading to a review by the accounting standard settlers of the accounting treatment of repo transactions.

[23]The consolidation models under IFRS and GAAP are relatively similar and are based on the criteria of entity control over the SPV.

[24]The acceptance of securitised notes as collateral in the ECB facilities led to an important increase in retention levels during the Eurozone crisis, with overall retention as a proportion of total gross issuance increasing from 26% in the first half of 2007 to 42% in the first half of 2012 (IMF (2013)).

example, from the central bank via repo, the receivables would become encumbered as it occurs in securities' financing transactions.

Figure 7 (left-hand side) illustrates how securitised receivables can be encumbered (highlighted in green) by collateralising ABSs that are either (i) sold to investors or (ii) used as repo collateral to obtain funding from another counterparty.

[Figure 7]

B.2.3 Covered bonds

Covered bonds are similar to MBS but the mortgages used as collateral always remain recognised on the consolidated balance sheet of the issuing entity and thus always generate encumbrance. The issuer and the investors have dual recourse to the collateral. This feature, together with the existence of overcollateralisation requirements and the dynamic replenishment of non-performing loans in the collateral pool imply that these instruments are perceived as being very safe. There is indeed no known default on covered bonds since their inception.

The use of covered bonds as collateral has significantly increased in recent times. For many banks in peripheral European countries (GIIPS) funding collateralised by retained covered bonds became the main source of long-term funding during the Eurozone sovereign crisis, as their access to unsecured markets was partially or fully closed (Van Rixtel and Gasperini (2013)).

B.2.4 Derivatives

Derivatives also generate encumbrance, as collateralisation has become a key method of mitigating counterparty credit risk in derivative markets, both on over-the-counter (OTC) and exchange-traded (ETD) derivatives. Collateralisation occurs because of the provisioning of the margin, in two different forms. A variation margin is posted during the course of the transaction to cover adverse changes in value (i.e. a negative mark-to-market value). Initial margin (also known as an independent amount) is posted at the beginning of a transaction to cover potential future adverse changes in the value of the contract, and is recalculated on a regular basis.

The margin provided is subject to restrictions and therefore constitutes encumbered assets. This is illustrated in figure 7 (right-hand side).[25] The margin can be provided in the form of cash

[25]The figure assumes that the variation margin is not offset against the derivative liability (i.e. the negative fair value from the derivative) therefore becoming encumbered. Some contracts allow for such an offsetting of the variation margin. The outstanding exposure between the counterparties is settled and the terms of the derivative contracts are reset so that the fair value is zero, leading to no encumbered assets due to an exchange of the variation margin.

or securities and it is common to provide re-hypothecation rights to the counterparty. According to the latest ISDA Margin Survey, for non-cleared OTC derivatives cash represents 76.6% of the collateral provided, followed by government bonds (13.4%) and other securities (10.1%), including US municipal bonds, government agency/government-sponsored enterprises (GSEs), and equities (ISDA (2015)).

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Figure 1. Model timeline

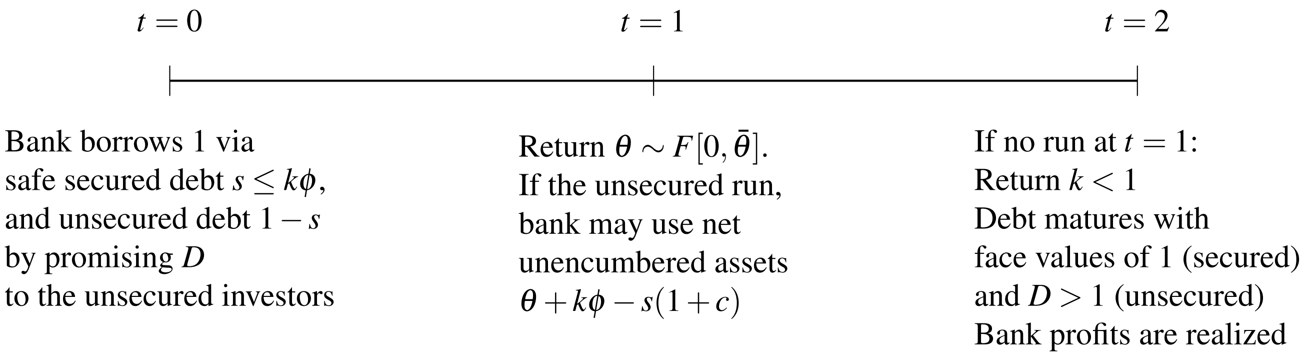

Figure 2. Optimal asset encumbrance and interest rate on unsecured debt for different levels of available collateral

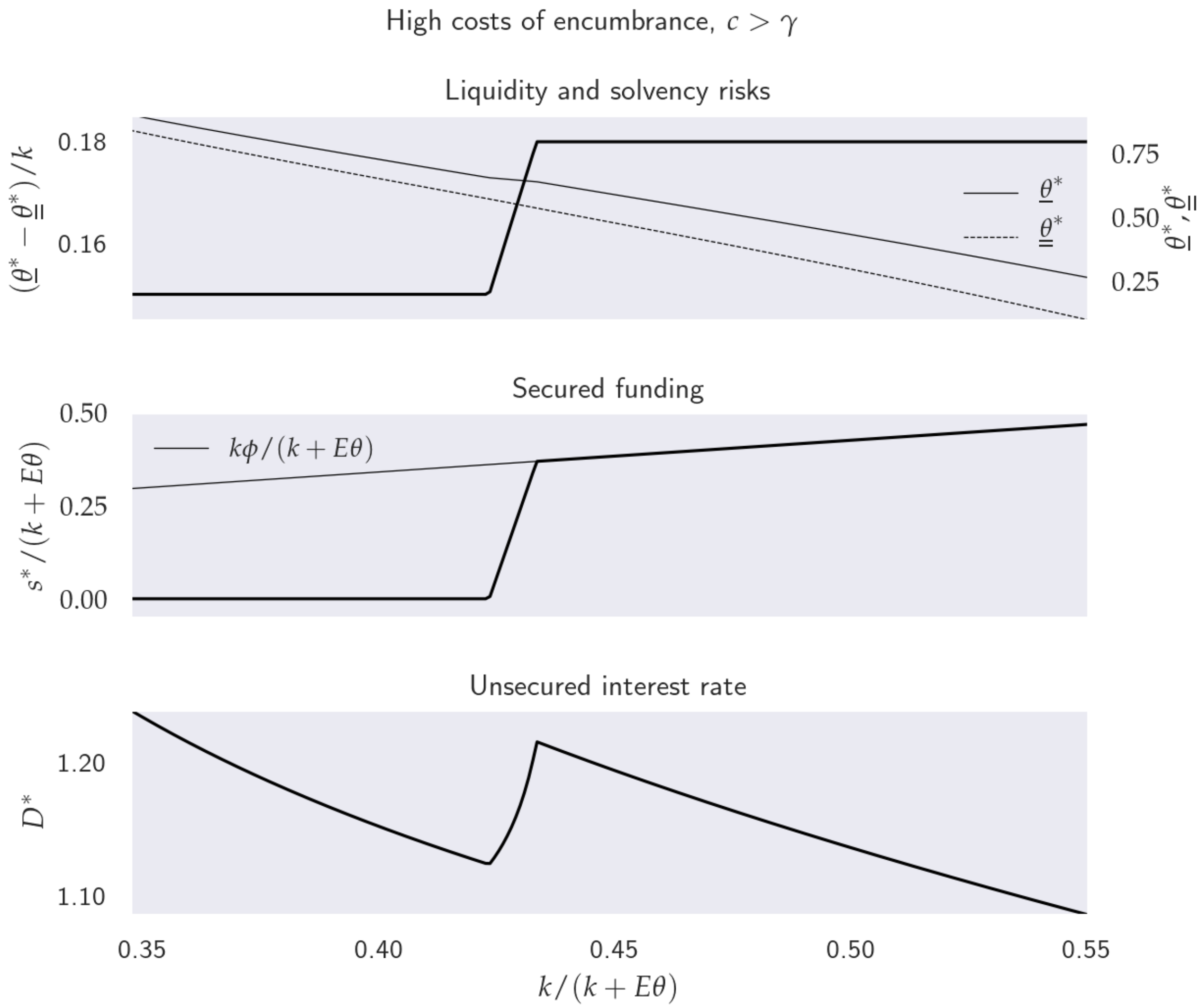

Figure 3. Optimal asset encumbrance and interest rate on unsecured debt for different levels of collateral prices

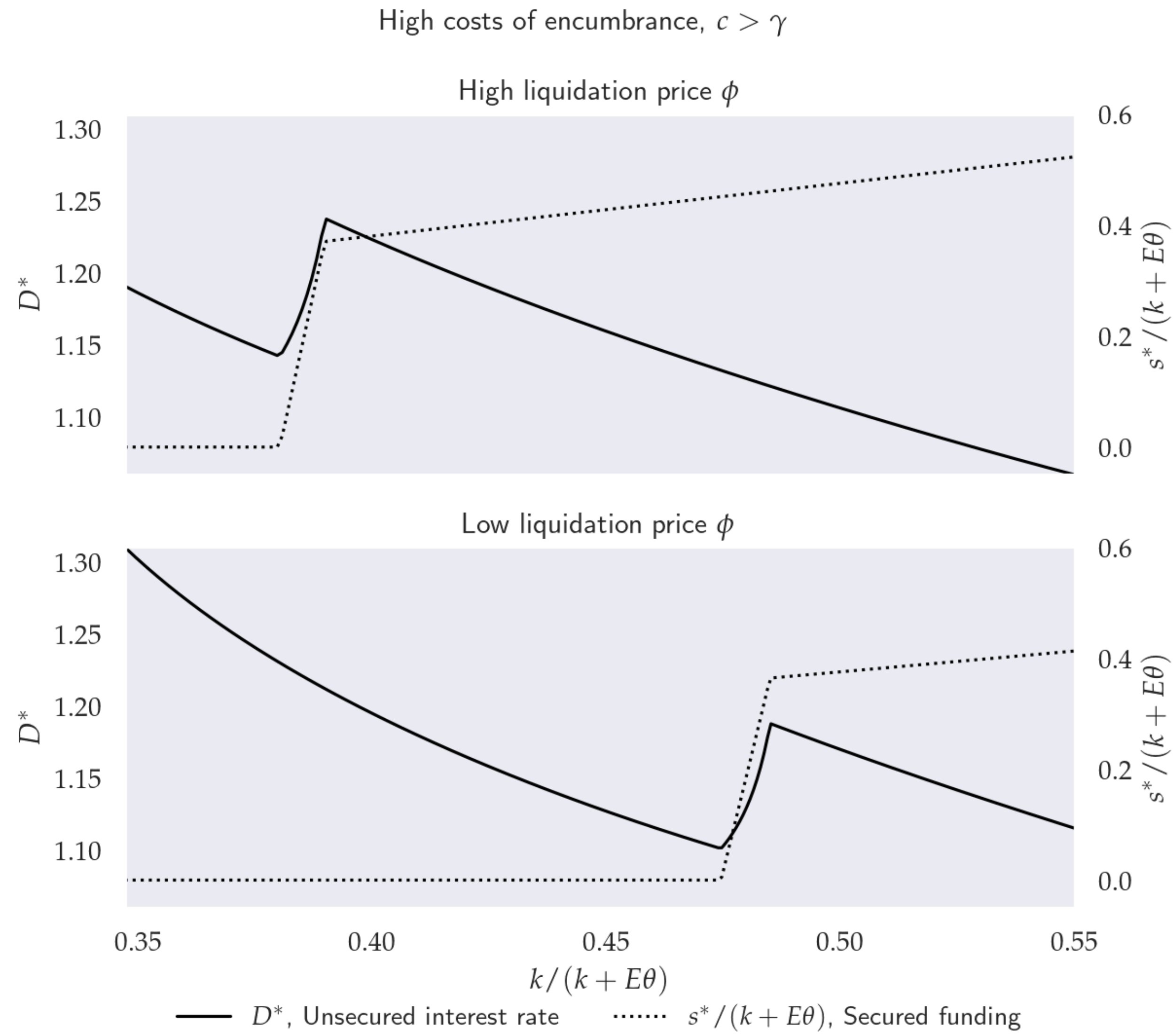

Figure 4. Asset encumbrance metrics

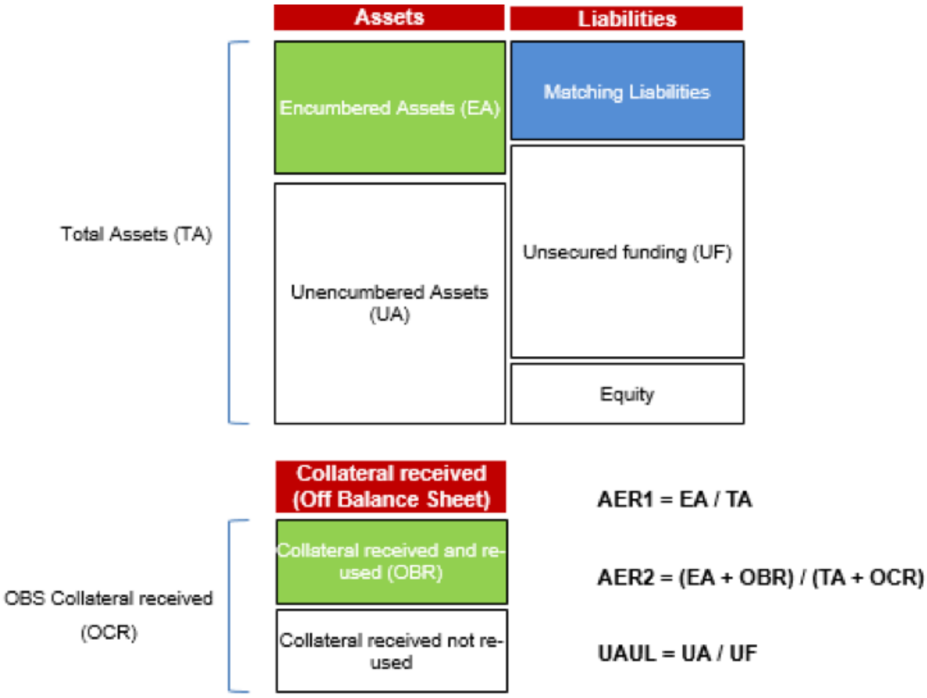

Figure 5. Encumbrance of assets when obtaining secured funding

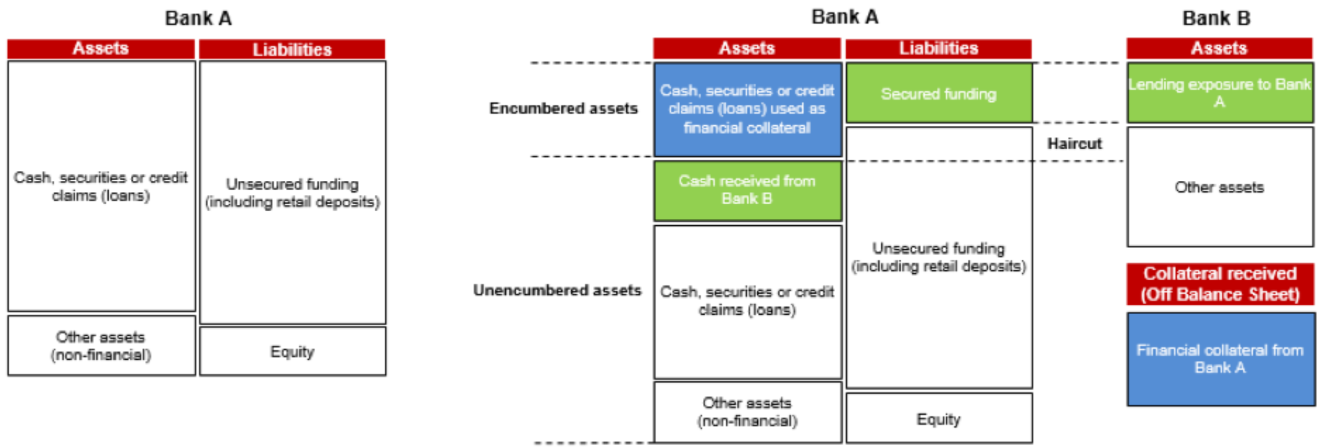

Figure 6. Collateral received and re-used

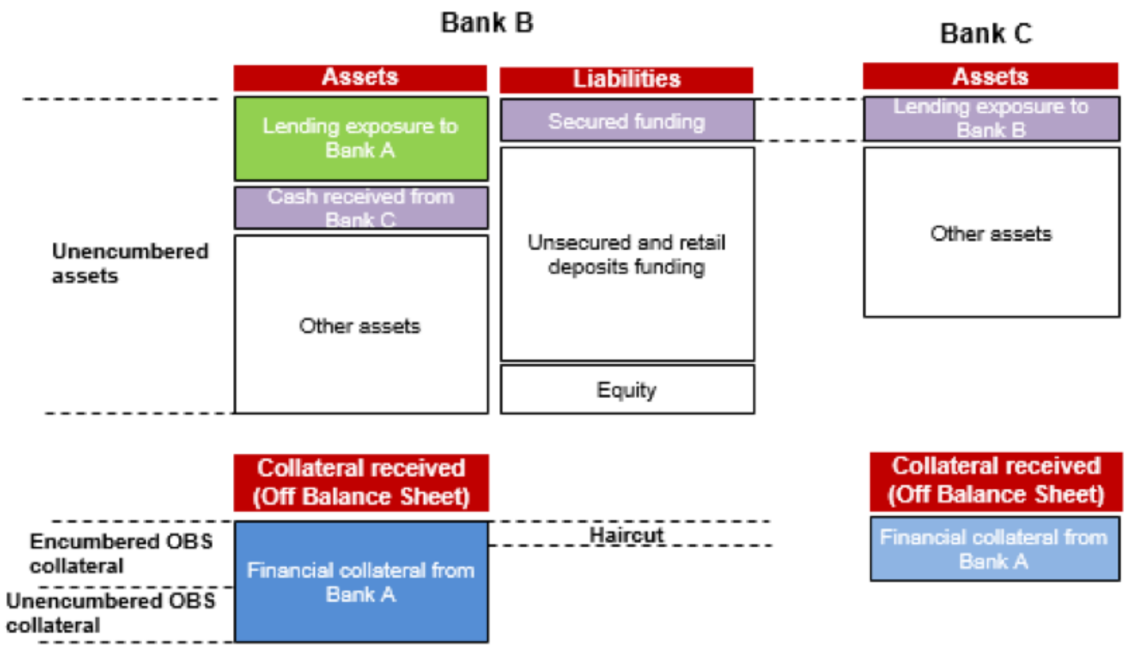

Figure 7. Encumbered and unencumbered assets from securitization and derivative transactions

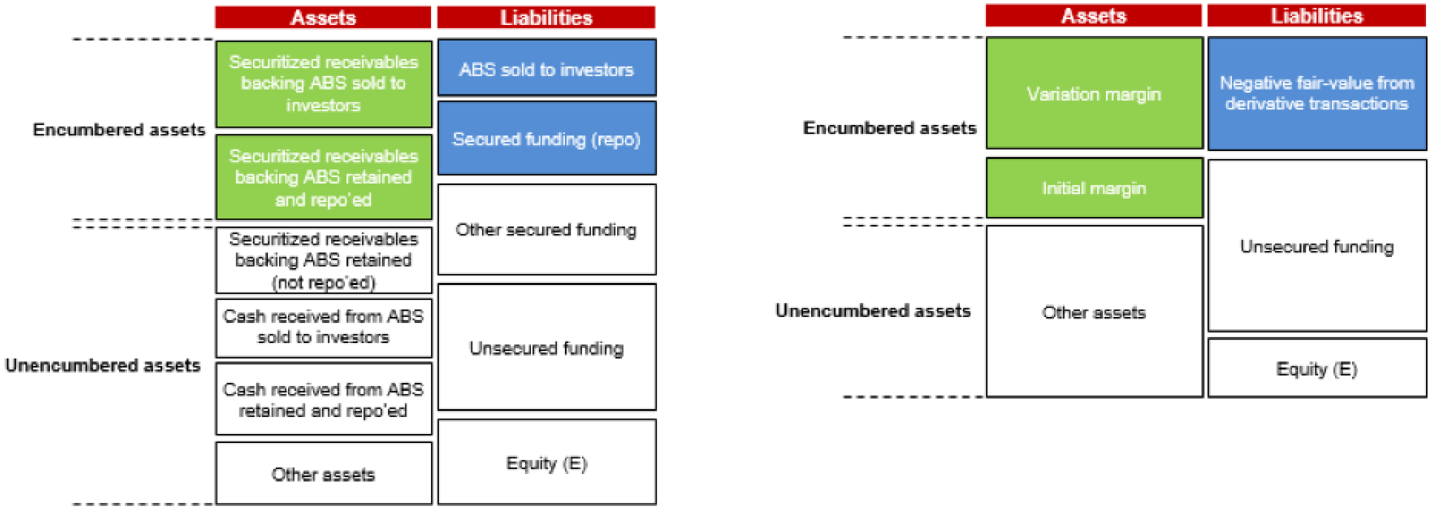

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Table 1. Summary of encumbrance measures

	Mean	Median	SD	Min	Max
AE	12.8	9.1	11.9	0.1	81.0
AE^{+}	13.2	9.3	12.2	0.1	81.0
ULUA	92.9	91.5	11.2	21.7	127.3

Encumbrance measures are in percentage points.
Number of banks is 534.

Table 2. Mean encumbrance levels by rating, size and business model

	AE	AE^+	ULUA
By credit rating			
A	6.8	6.8	94.5
A/B	19.2	21.1	92.9
B	14.4	14.7	94.0
B/C	11.7	12.4	92.9
C	13.1	13.3	92.6
C/D	11.5	11.7	94.5
D	7.8	8.2	91.0
D/E	11.3	11.4	79.9
E/F	2.9	2.9	84.8
By bank size			
< 3.5 bn	10.0	10.3	92.3
3.5–15 bn	11.0	11.5	93.1
15–50 bn	24.4	24.8	95.9
50–170 bn	28.0	28.2	91.9
170–600 bn	28.1	28.6	100.0
> 600 bn	17.1	22.1	89.0
By bank type			
BHC & Commercial	19.2	20.2	93.9
Cooperative	11.6	11.8	94.1
Saving	8.9	9.4	91.1
Other	25.9	26.4	96.6

Encumbrance measures are in percentage points.
Number of banks is 534.

Table 3. Summary statistics of variables used in cross-sectional estimation

	Mean	Median	SD	Min	Max
ln CDS'15 ($\times$100)	506.67	504.45	26.97	454.23	639.47
ln AE	2.20	2.21	0.89	–1.99	4.39
ln AE^{+}	2.22	2.23	0.90	–1.99	4.39
ln ULUA	4.52	4.52	0.14	3.08	4.85
ln AE^{On+Off} / AE^{On}	0.07	0.00	0.20	0.00	1.06
ln TA^{On} / TA^{On+Off}	–0.04	0.00	0.16	–2.56	0.00
ln UL / TA	–0.23	–0.18	0.17	–1.60	–0.07
Loans to deposits	75.55	73.68	23.97	18.04	201.76
Liquid assets	12.63	9.02	11.02	1.50	69.25
Tier 1 ratio	14.76	14.04	3.99	7.53	32.71
ROA	0.21	0.21	0.38	–2.17	1.47
Unreserved impaired loans	23.89	12.46	33.92	0.28	199.30
Investment grade	0.69	1.00	0.46	0.00	1.00
GIIPS	0.17	0.00	0.38	0.00	1.00
Eurozone	0.94	1.00	0.24	0.00	1.00
ln CDS'14 ($\times$100)	512.23	503.06	30.76	459.59	609.18

Encumbrance measures and balance sheet ratios are in percentage points.
Number of banks is 534.

Table 4. CDS vs AE in a cross-section of banks

	(1)	(2)	(3)
ln AE	−7.6***	−3.5***	−3.0***
	(2.47)	(1.23)	(1.07)
Loans to deposits		−0.1	−0.1
		(0.07)	(0.08)
Liquid assets		0.0	−0.1
		(0.08)	(0.07)
Tier 1 ratio		0.3	0.3
		(0.25)	(0.33)
ROA		−12.2***	−13.7***
		(3.74)	(3.05)
Unreserved impaired loans		0.1*	0.0
		(0.04)	(0.04)
CB exposure		1.6***	0.9*
		(0.50)	(0.49)
Size		−4.7***	−5.6***
		(0.59)	(0.63)
Investment grade		−31.7***	−29.1***
		(3.34)	(2.30)
GIIPS		2.3	
		(3.80)	
Eurozone		−17.6***	
		(6.53)	
Country FE, Business model FE	n	n	y
R^2	0.06	0.60	0.67
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums (×100) of banks in 2015. All explanatory variables are as of end-2014.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5. CDS vs AE^+ in a cross-section of banks

	(1)	(2)	(3)
ln AE^+	–7.5***	–3.0**	–2.5**
	(2.43)	(1.16)	(0.95)
R^2	0.06	0.60	0.67
ln AE	–7.6***	–3.3***	–2.8**
	(2.52)	(1.23)	(1.05)
ln AE^{On+Off} / AE^{On}	–8.0	6.3***	7.6***
	(8.87)	(2.34)	(1.96)
ln TA^{On} / TA^{On+Off}	–0.1	–0.8	–1.4
	(5.06)	(2.33)	(2.32)
R^2	0.07	0.60	0.68
Controls	n	y	y
Country FE, Business model FE	n	n	y
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums (×100) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4.
Standard errors (in parenthesis) are clustered by the intersection of country and business model.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6. CDS vs ULUA in a cross-section of banks

	(1)	(2)	(3)
ln ULUA	–24.9*	–14.4*	–5.7
	(13.28)	(7.38)	(6.47)
R^2	0.02	0.60	0.67
AE	–0.5**	–0.3**	–0.2**
	(0.21)	(0.10)	(0.09)
ln UL / TA	−11.3	−11.4	−2.1
	(13.22)	(7.59)	(6.31)
R^2	0.04	0.60	0.67
Controls	n	y	y
Country FE, Business model FE	n	n	y
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ($\times$100) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7. CDS vs AE in a cross-section of banks (all CAMELs)

	(1)	(2)	(3)
ln AE	-7.6^{***}	-2.7^{**}	-2.6^{**}
	(2.47)	(1.13)	(1.02)
Liquid assets		0.0	−0.1
		(0.08)	(0.07)
Loans to deposits		-0.1^{*}	-0.1^{*}
		(0.06)	(0.07)
Tier 1 ratio		0.0	0.3
		(0.39)	(0.46)
Equity to assets		0.4	−0.4
		(0.78)	(0.71)
ROA		5.9	4.6
		(9.65)	(9.55)
ROE		-1.5^{**}	-1.4^{**}
		(0.62)	(0.62)
Unreserved impaired loans		0.0	0.0
		(0.05)	(0.05)
Loan loss reserves		1.4^{***}	0.9^{**}
		(0.42)	(0.41)
CB exposure		1.2^{**}	0.8^{*}
		(0.47)	(0.48)
Size		-4.5^{***}	-5.6^{***}
		(0.59)	(0.64)
Investment grade		-29.8^{***}	-28.2^{***}
		(2.34)	(2.15)
GIIPS		−0.9	
		(4.16)	
Eurozone		-19.1^{***}	
		(6.02)	
Country FE, Business model FE	n	n	y
R^2	0.06	0.63	0.68
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums (×100) of banks in 2015. All explanatory variables are as of end-2014.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8. CDS vs AE in a cross-section of banks: controls for past level of credit risk and weighted regressions

	(1)	(2)	(3)	(4)	(5)	(6)
ln AE	−1.9***	−1.6***				
	(0.43)	(0.44)				
ln AE^{+}			−1.6***	−1.4***		
			(0.49)	(0.51)		
ln ULUA					−12.3***	−8.4**
					(2.67)	(3.22)
ln CDS'14 (×100)	0.5***	0.5***	0.5***	0.5***	0.5***	0.5***
	(0.04)	(0.02)	(0.04)	(0.02)	(0.04)	(0.02)
R^2	0.79	0.81	0.79	0.81	0.79	0.81
# observations	528	528	528	528	528	528
ln AE	−7.7***	−7.9***				
	(2.19)	(2.25)				
ln AE^{+}			−6.8*	−6.5*		
			(3.70)	(3.72)		
ln ULUA					−30.8***	−29.3***
					(9.74)	(11.00)
R^2	0.71	0.79	0.70	0.78	0.71	0.78
# observations	534	534	534	534	534	534
Controls	y	y	y	y	y	y
Country FE, Business model FE	n	y	n	y	n	y
# clusters	62	62	62	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums (×100) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4. Standard errors (in parenthesis) are clustered by the intersection of country and business model.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9. Summary statistics of variables used in panel estimation

	Mean	Median	SD	Min	Max
ln CDS (×100)	477.19	481.84	41.50	360.72	574.98
ln AE	2.88	3.02	0.82	0.17	4.59
Loans to deposits	80.61	84.65	28.57	1.57	145.12
Liquid assets	19.12	14.79	17.17	1.37	97.33
Tier 1 ratio	15.37	13.70	8.49	7.71	76.50
ROA	0.18	0.22	0.75	−2.85	2.47
Unreserved impaired loans	44.41	26.99	46.17	0.08	214.13
CB exposure	2.51	0.35	4.76	0.00	31.35
Size	3.91	3.88	2.17	0.05	7.55
Δ *ln* CDS (×100)	−3.92	−0.26	23.75	−90.47	55.88
Δ *ln* AE	0.02	0.00	0.39	−1.39	1.51
Δ Loans to deposits	−0.89	−0.58	10.79	−63.01	70.87
Δ Liquid assets	0.07	0.14	4.61	−37.30	14.65
Δ Tier 1 ratio	1.27	0.70	4.27	−4.68	36.60
Δ ROA	0.02	0.02	0.76	−3.05	3.07
Δ Unreserved impaired loans	−1.13	−0.76	14.17	−50.14	59.06
Δ CB exposure	0.33	0.00	2.44	−10.43	14.85
Δ Size	−0.03	0.00	0.24	−1.40	1.55

Encumbrance measures and balance sheet ratios are in percentage points.
Number of banks is 99.

Table 10. CDS vs AE in a panel of banks

	Levels		Differences	
	(1)	(2)	(3)	(4)
ln AE	–9.2*	–6.2***	–6.3**	–6.8**
	(4.77)	(2.25)	(2.77)	(2.62)
Loans to deposits		–0.1		0.0
		(0.13)		(0.13)
Liquid assets		0.2		0.4
		(0.25)		(0.28)
Tier 1 ratio		–0.1		0.1
		(0.16)		(0.17)
ROA		3.7**		4.6**
		(1.66)		(1.90)
Unreserved impaired loans		0.3***		0.2***
		(0.06)		(0.08)
CB exposure		0.0		–0.1
		(0.37)		(0.46)
Size		3.0		–0.1
		(3.84)		(4.40)
Bank FE	n	y	n	n
Year FE	y	y	y	y
R^2	0.12	0.96	0.74	0.77
# observations	297	297	198	198
# banks	99	99	99	99

The dependent variable in all regressions is the average log of daily implied CDS premiums ($\times$100). All explanatory variables are lagged by one year.
Standard errors (in parenthesis) are clustered by bank.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11. Factor loadings of CAMEL variables

	Component 1	Component 2
Loans to deposits	–0.035	0.685
Liquid assets	–0.062	–0.682
Tier 1 ratio	0.357	–0.132
ROA	0.668	0.172
Unreserved impaired loans	–0.649	0.132

Factor loadings after orthogonal varimax rotation.

Table 12. Capital, liquidity and asset encumbrance

	(1)	(2)	(3)	(4)	(5)	(6)
ln AE	–9.4***	–3.0***	–5.7**	–2.2**	–7.4***	–2.3**
	(2.61)	(1.06)	(2.36)	(0.98)	(2.56)	(0.97)
ln AE × Capital	–0.4	0.0			–0.3	0.4
	(2.00)	(1.04)			(1.45)	(1.04)
ln AE × Illiquidity			5.5***	2.8***	4.8***	2.9***
			(1.22)	(0.92)	(1.16)	(0.92)
Capital	–7.1**				–7.1***	
	(2.71)				(1.95)	
Illiquidity			–5.6***		–6.0***	
			(2.05)		(2.03)	
Controls	n	y	n	y	n	y
Country FE, Business model FE	n	y	n	y	n	y
R^2	0.13	0.67	0.13	0.68	0.20	0.68
# observations	534	534	534	534	534	534
# clusters	62	62	62	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums (×100) of banks in 2015. All explanatory variables are as of end-2014. Controls are similar to the ones in Table 4.

Capital and Liquidity are bank scores based on the first two principal components of correlation matrix of CAMEL variables; both are centered and standardized to have unit variance.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$